Survey Harmonisation with New Technologies Improvement (SHANTI)

Armoogum, Jimmy; Bonsall, Peter; Browne, Michael; Christensen, Linda; Cools, Mario; Cornélis, Eric; Diana, Marco; Guilloux, Tristan; Harder, Henrik; Reinau, Kristian Hegner

Total number of authors:
19

Publication date:
2014

Document Version
Publisher's PDF, also known as Version of record

Jimmy Armoogum
Editor

SURVEY HARMONISATION WITH NEW TECHNOLOGIES IMPROVEMENT (SHANTI)

cost
Recherches

Jimmy Armoogum
Editor

Survey Harmonisation with New Technologies Improvement (SHANTI)

RECHERCHES

Avril 2014

The Editors

Dr. Jimmy Armoogum
UPE, Ifsttar, DEST
14-20 Boulevard Newton, Cité Descartes, Champs sur Marne, F-77447 Marne-la-Vallée, France

Prof. Peter Bonsall
Emeritus Professor
Institute for Transport Studies (ITS)
36-40 University Road
University of Leeds, Leeds
LS2 9JT, United Kingdom

Prof.Michael Browne
Professor of Logistics
School of Architecture and the Built Environment
University of Westminster
35 Marylebone Rd London
NW1 5LS, United Kingdom

Dr. Linda Christensen
Senior Researcher
DTU Transport, Technical University of Denmark
Bygningstorvet 116B, Building, 2800 Kgs. Lyngby, Denmark

Dr. Mario Cools
Local Environment Management and Analysis (LEMA), Université de Liège, Chemin de Chevreuils 1, Bât B52/3, 4000 Liège, Belgium

Dr. Eric Cornélis
Senior Research Associate
Université de Namur, Transportation Research Group (GRT)
Rempart de la Vierge 8
B 5000 Namur, Belgium

Dr. Marco Diana
Dipartimento di Idraulica, Trasporti e Infrastrutture Civili
Politecnico di Torino
Corso Duca degli Abruzzi, 24 10129 Torino, Italy

Tristan Guilloux
Cerema, Department for sustainable mobility
2, rue Antoine Charial CS 33927-69426 Lyon cedex 03

Prof.Henrik Harder
Associate Professor, Ph.D.
Department of Architecture, Design and Media Technology, Aalborg Univeristy
Østeraagade 6, DK 9000 Aalborg, Denmark

Prof.Kristian Hegner Reinau
Associate Professor, Ph.D.
Department of Architecture, Design and Media Technology, Aalborg Univeristy
Østeraagade 6, DK 9000 Aalborg, Denmark

Dr. Jean-Paul Hubert
UPE, Ifsttar, DEST
14-20 Boulevard Newton, Cité Descartes, Champs sur Marne, F-77447 Marne-la-Vallée, France

Dr. Martin Kagerbauer
Karlsruhe Institute of Technology (KIT) – Institute for Transport Studies
Kaiserstrasse 12, D-76131 Karlsruhe, Germany

Dr. Tobias Kuhnimhof
Transportation Engineer, Institute for Mobility Research (ifmo), Petuelring 130, 80788 Munich, Germany

Dr. Jean-Loup Madre
UPE, Ifsttar, DEST
14-20 Boulevard Newton, Cité Descartes, Champs sur Marne, F-77447 Marne-la-Vallée, France

Anastasia Moiseeva
Eindhoven University of Technology,Urban Planning Group,
PO Box 513,5600 MB Eindhoven, The Netherlands

Prof.John Polak
Professor of Transport Demand, Imperial College London, South Kensington Campus, London SW7 2AZ, United Kingdom

Angelika Schulz
German Aerospace Center (DLR) – Institute of Transport Research, Rutherfordstrasse 2, D-12489, Berlin, Germany

Maria Tébar
Cete de Lyon and UPE, Ifsttar, DEST,
25, Avenue François Mitterand, 69674 Bron, France

Lycurgo Vidalakis
Politecnico di Torino - Interuniversity Department of Regional and Urban Studies and Planning (DIST), Viale Mattioli, 39, 10125 Torino, Italy

COST Description

COST - European Cooperation in Science and Technology is an intergovernmental framework aimed at facilitating the collaboration and networking of scientists and researchers at European level. It was established in 1971 by 19 member countries and currently includes 35 member countries across Europe, and Israel as a cooperating state.

COST funds pan-European, bottom-up networks of scientists and researchers across all science and technology fields. These networks, called 'COST Actions', promote international coordination of nationally-funded research.

By fostering the networking of researchers at an international level, COST enables break-through scientific developments leading to new concepts and products, thereby contributing to strengthening Europe's research and innovation capacities.

COST's mission focuses in particular on:

- Building capacity by connecting high quality scientific communities throughout Europe and worldwide;
- Providing networking opportunities for early career investigators;
- Increasing the impact of research on policy makers, regulatory bodies and national decision makers as well as the private sector.

Through its inclusiveness, COST supports the integration of research communities, leverages national research investments and addresses issues of global relevance.

Every year thousands of European scientists benefit from being involved in COST Actions, allowing the pooling of national research funding to achieve common goals.

As a precursor of advanced multidisciplinary research, COST anticipates and complements the activities of EU Framework Programmes, constituting a "bridge" towards the scientific communities of emerging countries. In particular, COST Actions are also open to participation by non-European scientists coming from neighbour countries (for example Albania, Algeria, Armenia, Azerbaijan, Belarus, Egypt, Georgia, Jordan, Lebanon, Libya, Moldova, Montenegro, Morocco, the Palestinian Authority, Russia, Syria, Tunisia and Ukraine) and from a number of international partner countries.

COST's budget for networking activities has traditionally been provided by successive EU RTD Framework Programmes. COST is currently executed by the European Science Foundation (ESF) through the COST Office on a mandate by the European Commission, and the framework is governed by a Committee of Senior Officials (CSO) representing all its 35 member countries.

More information about COST is available at www.cost.eu.

This publication is supported by COST

Summary

The transport sector is one of the major sources of global warming, both from individual travel behaviour (especially car use) and from freight transport (mainly by trucks). Mobility surveys, as well as data collections about travel behaviour, are essential to develop transportation policies and measures which encourage more environment-friendly transport modes. Data quality is a real challenge, mainly because response rates are declining and interviewees are more and more reluctant to respond to burdensome questionnaires. Furthermore, harmonized data are a must for authorities, but in Europe different approaches and data qualities exist. The data needs from the transport sector allow the assessment of past policies, in terms of efficiency and equity. They allow the elaboration of new policies measures at European level (e.g. to reduce the emissions due to transport).

Mobile communication and positioning technologies including GPS/GALILEO, GSM and Radio Data System (RDS) have advanced rapidly and their costs are decreasing. They demonstrate great potential as survey instruments for tracking individual mobility and travel behaviour as well as freight movements, by enabling to conduct surveys along longer periods (e.g. a week instead of a day) and providing more accurate data on the spatial and temporal frameworks of travels, together with a relatively low burden for interviewees. Hence, We are at a turning point where aiming at producing guidelines towards European harmonized travel surveys should not miss the opportunities of an advancement by means of new information and communication technologies.

The purpose of this Action was to coordinate research efforts on data harmonization for transport surveys across Europe. Guidelines for harmonizing surveys are not only a statistical problem, because each country also needs to analyze survey results throughout time (time series in the perspective of previous surveys on the same thematic issues with normally the same design) and changing the protocol or the definitions may have an impact on indicators in the sense that the changing behavior could be confused with changes in methodology. Therefore, institutions are often not willing to follow international guidelines in changing design that has proven successful on the national level. Therefore a bottom up approach relying on the skills of the researchers involved in the field of national travel surveys and so quite well knowing their particularities were more promising and lead to more acceptable guidelines. To make results of different survey approaches comparable – it was necessary to develop a methodology or heuristic in which way a transition from one design to another can be derived and how the results of either survey approach can be “translated” or transformed into the results of another. On another hand, several New European Member states which are willing to install travel or transport surveys benefited of experiences and best practices from expertise out of the network. The Action built bridges between European countries as well as among researchers, enhancing research and disseminating recommendations throughout European society.

Besides the potential impact on important European policies, other benefit is the quality of data that underlie influential aggregate indicators since this issue is a

major concern for decision-making. Through working with the data and collaborating with the agencies supplying them, researchers provided important feedback on collection and measurement issues and how they can be improved. These issues include sampling methods, conceptual definitions of variables, questionnaire design, weighting schemes, collection procedures, electronic assembly, and data processing. All of these are crucial issues in ensuring accurate data, which are the basis for economic assessments.

Following the first main input of the project, getting harmonized data on a European Level may also be useful for developing analysis of inequities across Europe (e.g. by gender or region). Furthermore harmonized data allows the applicability of best practice examples in transport policy and the implementation of measures from one country to another – a question which becomes more and more relevant against the background of the climatic change. This issue is covered within this Action since that these developments should fulfill adequate and effective European policy measures.

Contents

Tables

Figures

Survey Harmonisation with New Technologies Improvement (SHANTI)

1 Introduction

The transport sector is one of the major sources of global warming, both from individual travel behaviour (especially car use) and from freight transport (mainly by trucks). Mobility surveys, as well as data collections about travel behaviour, are essential to develop transportation policies and measures, which encourage more environment-friendly transport modes. For achieving these goals, various data collection methodologies have been proposed in recent decades in different national or regional contexts. The need for a wider range of demand indicators on more detailed sub-populations and regional contexts is rising. Beyond that data quality is a real challenge, mainly because response rates are declining and interviewees are more and more reluctant to respond to burdensome questionnaires.

Therefore researchers have to reduce the number of questions and to develop methodologies improving data quality and compensating for these cuts, by either combining data sources (for example imputing travel cost from expenditure surveys) or by using new technological tools.

Harmonized data are a must for authorities on a European level. But in Europe different approaches and data qualities exist. The demand data from the transport sector should allow the assessment of past policies, in terms of efficiency and equity. They should also allow the elaboration of new policies measures at European level (e.g. to reduce the emissions due to transport).

Moreover travel surveys are burdensome (mainly due to the large number of questions and the repetition of the same items such as location, mode, purpose, etc.). It's therefore challenging to set up methods allowing comparisons of travel behaviour both among European countries and with data collected by each country in past surveys. Promoting new technologies (e.g. experiences with Global Positioning System GPS which should be generalized with GALILEO) could help for this harmonization of concepts and methods.

In an era where behaviour is changing, e.g. as a result of the rapid increase of fuel price, most countries only collect data about travels with a very low frequency (e.g. with a ten years delay) and therefore their mobility indicators are often obsolete and irrelevant for representing current mobility behaviours. Hence an important issue is a continuous data collection – to enable researchers to understand the underlying processes and the resulting behaviour and reactions, respectively. It is already the case for Continuing Survey of road freight transport harmonized by EUROSTAT (but data on energy consumption don't exist in all countries and aren't centralized) and for National Travel Surveys (NTSs) in few countries (the Netherlands, U.K., Denmark and Germany). Thus such continuous surveys would be a quite suitable tool for enabling to understand more about elasticity's or about the abilities of individuals to adapt their behaviour.

Differences across countries in the methodologies and concepts for measuring mobility and travel behaviour, sampling, and other procedures can be substantial at the micro level as well as for the outcome of a survey. These differences not only impede the construction of accurate and comparable aggregate indicators

but they also prevent researcher's s from drawing conclusions and inferences from comparative research. Such questions about accuracy and comparability of measurement are particularly salient in the case of new EU Member States such as the transition economies. In these countries, the institutions of data collection and variable definition developed differently during the central planning period, and therefore require special attention to understand their idiosyncrasies and how they might be improved and adjusted to increase comparability.

1.1 Current state of knowledge

Some national surveys have already been harmonized by EUROSTAT: expenditure surveys and time use surveys (from which only very rough information can be derived about mobility). But it is not the case for every day's mobility, even if sustainable transport is a strategic issue for Europe (see the 2011 White Paper). While mobility surveys with a local or regional focus are conducted in many urban areas all over the world, National Travel Surveys (NTSs) exist essentially in Europe; they have already been conducted in about 20 countries and are planned elsewhere but often using different methodologies, which make comparisons difficult or even impossible. The only experience of a harmonized survey is the FP5 DATELINE project (following suggestions from MEST and TEST FP4 projects) on long distance travels, however with methodological difficulties not yet overcome for a consistently estimating of trip made in the 100-400 km range. For tourism the FP5 ARTIST project should be mentioned. For freight, Road Good Transport surveys have been harmonized by EUROSTAT, but suggestions arisen from MYSTIC FP5 project for a shipper survey have been only followed in France (through the ECHO survey in 2004), while in US the truck survey is stopped and a simpler shipment Commodity Flow Survey is conducted every 5 years.

The results of the FP6 project KITE show on one hand the need but on the other hand also the limits of using data from different sources for comparison.

1.2 Presentation of different national travel in Europe

1.2.1 The Shanti wiki

The Shanti Wiki (http://shanti-wiki.inrets.fr/) is built up to connect members of various working groups and to interchange informations of different partners and different countries to have a platform to link data.

This wiki lives and dies with the participating of every member! The SHANTI-group members are asked to complete their pages, the page of their country with general information (e.g. contact persons) and especially the NTS-pages. This is really simple and the guiding idea of a wiki is, that everyone can share his knowledge easily with other interested persons.

To complete an existing page, click in [edit] on the right side of the paragraph or on the top of the page. You get to the editor, where you can write, delete and

complete the article. Finishing your work, you click to “Save page” on the bottom of the window, and your article has changed.

To get a list of all pages in this wiki, see the page

http://shanti-wiki.inrets.fr/index.php/Special:AllPages, or in the menu on the left side.

Below you find an overview of every participating country with the NTS. Clicking on the name of the country you are interested in, you get directed to a non-specific page with general informations about the country, the members in SHANTI and so on. In the table you find the NTS listed by the years they run. To be able to read the names of the surveys hidden by the “x” you simply leave the cursor for some seconds on the field, the name, sometimes abbreviated, and appears. To get to the survey description with detailed informations you only have to click on it.

1.2.2 Maintenance of the wiki

Creating a New Page

1.2.2.1 New NTS

In a first step you have to insert an “ x ” in the Overview Table on the Main Page, in the right column (country) and in the right line (year). To get there you click on “edit” like on every other page situated on the top. Scrawling down to the section “Overview”, you find the table line by line. The first lines are for the countries; there you don’t have to do anything. The following lines are the years.

The first one of each section is the year in numbers, don’t touch at these lines.

|style=”background-color:#F2F2F2; color:#333333” height=”15” align=”center” valign=”bottom” | 1965

The following lines are the countries in this year, in alphabetical order. For finding your place to put in your “x” you first have find the section of the year, the position of your country in the alphabetical order of the existing countries (e.g. in the fifth line is France, after AU, BE, DK and DE. Other NTS in the same year can be helpful to keep the orientation).

When you’ve found your line, you replace the line (corresponding to the empty field the table) by this line with the specific information of your NTS at the right place:

Country
Name of NTS in your language
(ABBREVIATION)
and the
English name of the NTS
seperating the x with a straight slash like this: | x
|style=”background-color:#FFFF00” align=”center” | [[Country: Name of NTS in your language (ABBREVIATION); English name of the NTS straight slash x]]

Now, the most difficult part is done, clicking on “Save page” on the bottom you will see the table in its final version. If you’re not sure if everything went right, you can use the “Show preview” button first and if it’s okay like this, you can go on “Save page”.

Please verify if the “x” is at the right position, if not:

Go on “history” on the top of the page, next to the button “edit”, and click “undo” for the changes you’ve made.

Now you have inserted a red “x”. The red colour shows you, that there is no page behind this link. Clicking on the red “x” to get to an empty page with the name of your NTS like you’ve entered it in the Main Table.

Now its only copy+paste from the NTS scheme: newNTS and its done, you’re new NTS is ready to be filled in!

In the moment the new scheme is structured by titles and subtitles. The sections are described with a little text in italic letters. After filling in these sections you can delete the description, in order to keep the site clear.

1.2.2.2 New country

If there’s the need to add a new country, please contact the administrator (this is too complicated to explain it on this help page). Thx

1.2.3 Scientific Definitions

On the WikiPage Data Item Description you find a definition of the most common items. If you want to add something, don’t hesitate! For the beginning you can right your comments as text below the tables or you edit the tables. For the question of trip-based vs. activity-based you can have a look to:

“Travel Behaviour Survey - Data Collection Instruments”; Stecher, Bricka, Goldenberg; page 159 in “Conference on Household Travel Surveys: New Concepts and Research Needs”, National Research Council (U.S.). Transportation Research Board

2 Analysis of different methodology of national travel survey in Europe

Over the past forty years, many countries around the world have undertaken a National Household Travel Survey (NHTS) for the entire country. Scanning across Europe, North America, Australasia, and the Middle East, it appears that the Great Britain may have been the first country to undertake such a survey, having initiated this in 1965, followed the next year by France, and three years later by the USA. Since that time, many other countries have initiated National Travel Surveys, which have then been undertaken on a repetitive basis since inception.

2.1 A brief history

As noted in the Introduction, the earliest NHTS appears to have been the one conducted in the Great Britain in 1965. The purposes of that survey were primarily to provide a description of travel throughout the nation, and secondarily to provide information on long-term trends in travel. The survey sample was 7,545 households drawn from across Britain and it was conducted by face-to-face interview, with a self-completion travel diary left with each household member. Two interviewer visits were normally made to each household, the first to recruit the household and deliver the self-completion diaries, and the second to collect the diary and any remaining ancillary data. The Great Britain has since completed a further 5 surveys and has then run an annual survey since 1989.

After a first attempt in 1959 mainly focused on car ownership and use (Faure, 1963), the following year (1966-67), France conducted its first NHTS. The purposes of that survey were primarily to provide a description of travel throughout the nation, and secondarily to provide information for planning and sustainable development. The survey covered 22,000 households and was conducted by face-to-face interview, involving a minimum of two visits to sampled households. The French National Bureau of Statistics conducted the survey. The French NHTS was then repeated in 1973-74, 1981-82, 1993-94, and most recently in 2007-08. Thus, France has now conducted five NHTSs, at longer and longer time intervals, which is not too much of a problem, because changes in behaviour are slower and slower (e.g., saturation of car ownership).

Following these two NHTSs, the US Bureau of the Census undertook a nationwide household travel survey across the United States in 1969. This survey had the same primary purposes as the French one in 1966-67, namely to describe travel across the nation, and secondarily to support planning and sustainable development purposes. It covered a sample of 15,000 households, drawn from every state in the USA. The survey was conducted in 1969, 1977, and 1983 as a face-to-face interview, but has since been conducted as a telephone-based computer-assisted survey. This survey was initially named the Nationwide Personal Transportation Survey (NPTS) and it was try to be repeated every 5 years after 1969. In fact, the surveys took place in 1977, 1983, 1990, 1995, 2001, and 2008.

In 2001, the name of the survey changed to the National Household Travel Survey (NHTS), which is how it has been known for the most recent two surveys. The US has now conducted six such surveys since 1969.

2.2 Overview of recent National Travel Surveys in Europe

NTS are implemented with a variety of institutional settings in different European countries; in some of these, there is more than one data gathering effort in the transport sector that could more or less be seen as a NTS. To avoid misunderstandings, the NTS that are reviewed in this document are listed in the table below. More information on each of them is available in the SHANTI wiki.

Table 2.1: NTS in European countries

Country	Survey
Austria	Mobilitätserhebung österreichischer Haushalte (MÖH); Mobility Survey of Austrian Households
Belgium	BELDAM NTS Belgian Daily Mobility
Denmark	Transportvaneundersøgelsen (TU); Transport Behaviour Survey
Finland	Henkilöliikennetutkimus (HLT); National Travel Survey
France	Enquête Nationale Transports et Déplacements (ENTD); National Survey Transportations and Travel
Germany	Deutsches Mobilitätspanel (MOP); German Mobility Panel Mobilität in Deutschland (MID); Mobility in Germany
Italy	Osservatorio sui comportamenti di mobilità degli italiani (AUDIMOB) (*Italian mobility behaviours Observatory*)
Latvia	Iedzīvotāju pārvietošanās apsekojums 2003.g.; Passenger mobility survey
Netherlands	Onderzoek Verplaatsingen in Nederland (OViN); Movement Research in the Netherlands
Spain	MOVILIA Mobility Survey
Great Britain	National Travel Survey (NTS)
Israel	National Travel Habits Survey (NTHS)
Norway	Nasjonale Reisevaneundersøkelsen (RVU); National Travel Survey
Sweden	The National Swedish Travel Survey
Switzerland	Mikrozensus Verkehr; Microcencus Traffic

Source: Shanti Wiki

2.2.1 Main bodies involved

In most cases, National Travel Surveys depends on the department of transport of the government of the state, or other national authority, like in Finland the Finnish Transport Agency (former Road Administration) is involved in the process.

The survey is usually realized with the cooperation of a research institute and the National Statistic Bureau: INSEE in France, FSO in Switzerland, and CBS in the Netherlands.

Sometimes, like in Norway, Sweden, Denmark, Belgium and Switzerland, the local authorities participate into the survey. That's why it is recommended to advise the authorities of the intention of realizing the survey, the dates and the method that will be use. Local authorities will directly inform citizens about survey. In Germany (MID), the sample is drawn by the communities' registration offices, but beyond that no other authority is involved. Survey material was mailed by Infas (company responsible for fieldwork). Other local authorities (e.g., the City of Munich) did contract regional sub-samples for their particular region. However, they were not involved in conducting the survey itself.

The Italian case is different from the above, since the survey has a private and external sponsor like Fondazione BNC: this is a bank foundation traditionally engaged in the Transport sector, since the bank was formerly publicly owned and devoted to the development of railway transport. The survey is then realized by ISFORT, a private research facility that is owned by Fondazione BNC (80%) and the Italian State Railways (20%).

2.2.2 Ethics

Ethics describe minimum acceptable standards of conduct or practice. In travel surveys, this relates to how a survey agency conducts itself with respect to those interviewed. It also relates to a survey agency's actions following the data collection process when data are cleaned, coded, analysed, and archived.

According to NCHRP Report 571, it is recommended that the following ethical conduct be observed in all future travel surveys:

1. The anonymity of the persons surveyed, and the confidentiality of the information they provide, must be protected at all times;
2. A survey respondent may not be sold anything or asked for money as part of the survey;
3. Persons must be contacted at reasonable times to participate in the survey and must be allowed to reschedule participation in the survey to a different time if that is more convenient for them;
4. Survey personnel must be prepared to divulge their own name, the identity of the research company they represent, the identity of the agency that commissioned the study, and the nature of the survey being conducted, if requested by a respondent;
5. Children under the age of 15 may not be interviewed without the consent of a parent or responsible adult;
6. A respondent's decision to refuse participation in a survey, not answer specific questions in the survey, or terminate an interview while in progress must be respected if that is the respondents' firm decision;

7. Respondents may not be surveyed or observed without their knowledge: methods of data collection such as the use of hidden tape recorders, cameras, one-way mirrors, or invisible identifiers on mail questionnaires may only be used in a survey if the method has been fully disclosed to the respondent and the respondent agrees to its use;
8. A research agency may not release research findings prior to the public release of the findings by the organization that commissioned the study, unless approval of the client organization is obtained to do so;
9. A research agency must ensure the reasonable safety of its fieldworkers during the execution of a survey.

This code leads to a discussion in some of the points in the Shanti context:

– Point n° 7: for NTS is not a problem, but what about automatic recording like with GSM?

– Point n° 8: Denmark does not comply: Interviews are used for research here at their department shortly after collection, but officially the data are only released to the sponsoring partners twice a year. It might say that this is by "approval", because it is no secret. - But the reality is that the standard is broken there.

– We have to be careful if it is reasonable when new technologies are used.

In order to compare, it is also propose © 2008 ICC/ESOMAR International Code on Market and Social Research create in 1977 and update in 1986 and 1994:

The Code is based on these key fundamentals:

1. Market researchers shall conform to all relevant national and international laws.
2. Market researchers shall behave ethically and shall not do anything, which might damage the reputation of market research.
3. Market researchers shall take special care when carrying out research among children and young people.
4. Respondents' cooperation is voluntary and must be based on adequate, and not misleading, information about the general purpose and nature of the project when their agreement to participate is being obtained and all such statements shall be honoured.
5. Market researchers shall respect the rights of respondents as private individuals and they shall not be harmed or adversely affected as the direct result of cooperating in a market research project.
6. Market researchers shall never allow personal data they collect in a market research project to be used for any purpose other than market research.
7. Market researchers shall ensure that projects and activities are designed, carried out, reported and documented accurately, transparently and objectively.
8. Market researchers shall conform to the accepted principles of fair competition.

2.2.3 Overview of the availability of information from National Travel Surveys implemented in Europe

2.2.3.1 The relevance of the topic for the transport research community

Data collection activities in the transport sector represent an invaluable source of information for all the relevant actors that deal with mobility and travel systems and services: researchers, consultants, entrepreneurs, manufacturers, services operators, public decision makers, travellers and communities. Yet there are often different kinds of barriers that, in common practice, make it difficult to circulate such data. These barriers therefore severely limit the potential utility that such information sources might have for European stakeholders. In turn, in times of financial restrictions this might cause an underestimation of the real value of pursuing such efforts, that could be the prelude of fatal decisions of disinvestments in these activities if their importance is only clear to a restricted elite of researchers.

The information barriers that we are analysing here are not related to aspects such as the regulatory and policy frameworks in different countries concerning the use of data from public surveys, the need to protect privacy by avoiding the release of information that could allow the identification of the respondents or the technical skills that are actually needed to access, understand and exploit such information. Here we focus on much more practical matters, generally related to the lack of knowledge of the procedure that must be suit to obtain a given information, and that might erroneously induce one to think that such information is not accessible or, even worse, not existing. It was surprising even for many travel survey specialists inside the SHANTI network to discover the amount of information that is more or less readily available concerning national travel surveys in many countries, once the formal procedures to get such data are clearly laid down.

2.2.3.2 Information on NTS data availability included in the SHANTI wiki

Given the strategic importance of such topic, within SHANTI activities it was decided to try to give a contribution to the abatement of such barriers. This was achieved through the development of a specific section in the SHANTI wiki pages, in which detailed and practical information can be found for many surveys on how to access information concerning several different aspects of a typical national travel survey. As a cautionary note, we point out that such information in most cases was collected in 2010 and there could have been changes in more recent years.

In general terms, accessibility conditions to information related to a given NTS vary in most countries according to the following two aspects:

The entity that is asking information and the subsequent intended use of such information.

The kind of information being requested:

Therefore, a categorization of these two aspects allowed us to operatively define the procedures that need to be followed and the conditions that are to be

fulfilled to access the information. Concerning the former aspect, the following four categories have been defined:

1. The applicant is working in a university or public research institution and s/he needs this information for teaching / for research (either publicly or privately funded, but results will be public) / for consulting of public bodies.
2. The applicant is working in a university or public research institution and s/he needs this information for a privately funded research or consulting activity, whose results will not be public.
3. The applicant is working in a private institution or as a professional consultant and s/he needs this information for teaching / for research (either publicly or privately funded, but results will be public) / for consulting of public bodies.
4. The applicant is working in a private institution or as a professional consultant and s/he needs this information for a privately funded research or consulting activity, whose results will not be public.

It is anticipated that, if accessibility conditions change across these categories, then they should become more stringent moving from the first to the fourth group.

Concerning the latter aspect, the following eight pieces of information that are typically sought from an NTS have been considered, in broad terms ranging from the most general to the more specific one:

1. An overall description of the survey
2. Survey design issues (e.g. sampling strategy)
3. Questionnaire contents
4. Variables codebook and metadata
5. Look up tables, cross tabulations and other descriptive statistics
6. Interactive analysis tools of the data
7. Survey micro data
8. Resulting O/D matrix

To date, the wiki pages that contain indications related to data accessibility are those related to the following 21 surveys, that we group here by country:

1. MOBEL (1998-99) and BELDAM (2009-2010) in Belgium
2. ENTC (1993-94) and ENTD (2007-2008) in France
3. NTS (1988-2008) in Great Britain
4. AUDIMOB (since 2008) and SIMPT (2004-2005) in Italy
5. RVU (1991-92, 1997-98, 2001, 2005) in Norway
6. MOVILIA (2000-2001 and 2006-2007) and Catalan Census (2001) and EMQ (2006) in Spain
7. RES (1999-2001 and 2005-2006) in Sweden
8. Microcensus (1994, 2000, 2005, 2010) in Switzerland.

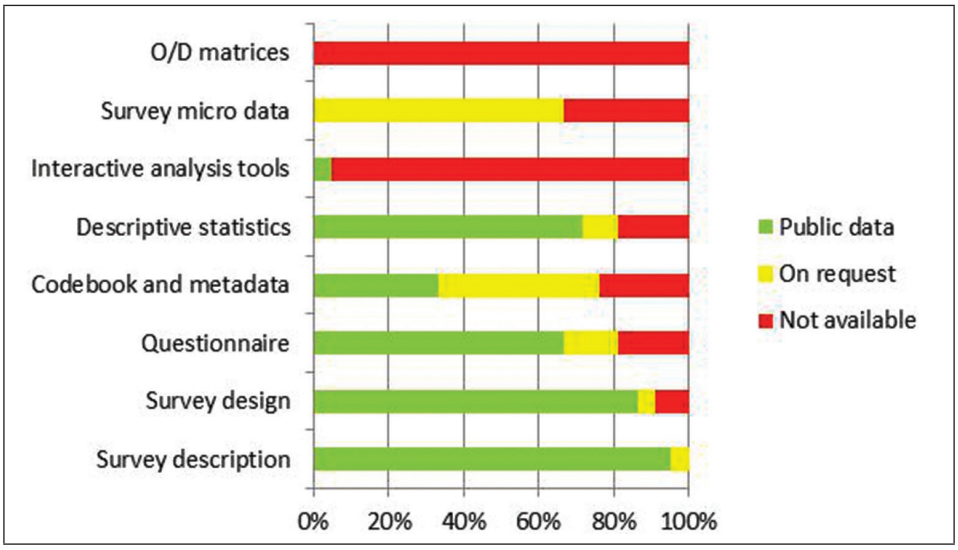
Each of these wiki pages clarifies the accessibility conditions for the eight above kinds of information for each of the four typical data users and usages that we identified. There are basically three accessibility condition levels:

- *Publicly accessible.* This means that the information is available, either electronically or through some printed publication. In this case, the wiki details how to access it (for example, giving full bibliographic references or the link to the relevant web page)
- *Available upon request*, some conditions might apply. In this case, the wiki details the procedure that needs to be followed to access the information: contact details of the institution or the person in charge of the diffusion, costs, restrictions and conditions that need to be taken into account, indication of application forms and letter of request etc.
- *Not available or not accessible.*

The interested reader is referred to the SHANTI wiki for detailed information. In the following, we limit ourselves to a short presentation on the general results concerning the overall accessibility conditions of the above listed surveys.

In the following figure, we show the percentages of NTS surveys, among the 21 considered ones, for which the selected piece of information is either publicly available, available on request or not available / not accessible. The results here presented are referred to an applicant working in a university or a public research institution that needs the data to drive a research with public results; when we consider the other three above cases, accessibility conditions were recorded to change especially for the two items “Codebook and metadata” and “Survey micro-data”.

Figure 2.1: Accessibility conditions to different pieces of information related to 21 European NTS



It can be seen that none of the selected surveys grants free and open access to the micro-data, contrary to the U.S. National Household Travel Survey. However, at least in principle in most cases such data can be obtained following a more or less complicated procedure and eventually paying some fees. O/D matrices from the data are not readily available, and only in one case an interactive online tool

has been set up to allow the researcher to perform customized analyses on data without having a direct access to them.

2.2.3.3 A focus on the availability of geographic information

Concerning the availability of O/D matrices, we soon realised that it was worth better clarifying some issues related to the accessibility of geographic-related information in more general terms, beyond what is actually reported on the wiki. It is in fact true that O/D matrices are generally estimated through models that in turn are fed by household surveys at different scales. There are several reasons for doing that, rather than directly estimating such matrices from survey data. Perhaps the two most immediate are related to the fact that the sample of households might not be automatically representative of origins and destinations on one hand, and the interest in linking O/D matrices to some determinants of travel behaviours to inform transport policies on the other.

Therefore, the above result related to the unavailability of O/D matrices from the reviewed surveys could have different explanations: O/D matrices have been directly built from data but not diffused (SHANTI experts are aware of similar cases, at least for surveys at smaller scale), O/D matrices could have never been built neither from the data nor through a modelling system (in some countries NTS are not implemented to feed a travel demand model), or O/D matrices from models have actually been obtained but are not available.

Given such situation, it was decided to complete the information on data availability through an additional round of consultations with the SHANTI experts. The focus has been on the availability of precise geographical information in the micro data. Beyond the above discussed utility of such information for modelling purposes and, to a lesser degree, to directly estimate O/D matrices, it also allows differentiating travel behaviours according to geographical variables, types of places, originally not included in the dataset. Of course, the main problem is that, with such information given either by codes, addresses or geocoding, it becomes possible in some cases to identify respondents so that confidentiality issues arise. The following box presents the questions that were asked to SHANTI experts at the beginning of 2013.

Questions related to the availability of geographical information

For the different travel surveys that we have considered in WG4 and you are familiar with:

1) Is there confidential geographical information archived in some database, even if such information is not accessible?

If yes,

2) Which one?
3) Could you please describe the level of detail of such localizations?
4) Which specific institutions can have access to these variables inside particular services?
5) Are there specific protocols for external researchers or practitioners willing to access such information?

The general findings of such mini-survey were the following. If contact addresses, as personal information, are generally deleted and always kept out of statistical datasets, addresses are geocoded to produce different levels of geographical information. Access to travel survey datasets may be different according to the kind geographical information they contain. The surveys in Europe do not have the same base level for geographical information. In some countries, addresses are geocoded into geographical coordinates of places (e.g. Denmark). In others, different kind of zones: census tracts, enumeration districts (UK), statistical sectors, municipality code (France), transport zones (Cataluña), or national spatial nomenclature (Germany MOP and MID) are the base levels. Some are considered as confidential with restricted access; some are not.

It may be added that, from one country to another, confidentiality is not seen at the level of geographical precision. In Denmark, where surveys feed a general transport model with a specific zoning, the zones minimum size is 200 inhabitants, which is not regarded as a threat to privacy. In France, the threshold is much higher (10.000 inhabitants) so that the municipality of residence, origin or destination of a trip is confidential and its access regulated by laws on privacy protection and statistical secret. The severity of the rule is related to the presence of more or less sensitive items in the questionnaire (e.g. nationality of the respondent, health…) and may be increased in the case of a mandatory survey.

Confidential datasets have a place of deposit and cannot normally be accessed from any other place, except special agreements which are not in our scope and distant secure access system that, to the best of our knowledge, only exist in France since 2010.

2.2.3.4 Summary of the main findings

From our review it is apparent that there is not a common European policy concerning the way to regulate the accessibility to the survey data. This has to do not only with national differences, but also with the different institutional settings under which such activities are carried out. For example, in some cases private or for-profit bodies initiated NTS, so that it is logical that accessibility conditions tend to be more stringent. In other cases, NTS have been organized for a specific purpose (i.e. to feed a transport planning model) and therefore there was no awareness on the added value of making this information available also for different purposes.

To sum up, it is surely desirable that greater uniformity on the accessibility conditions and procedures to the information related to national NTS is achieved in the near future across different European countries. From the point of view of the data user, it would of course be desirable to progressively lower the existing barriers, at least for those surveys sponsored with public money. If granting open access to all data like for the U.S. NHTS is something that is not felt viable, it would at least be advisable to set up a website or web page in which the procedures are clearly spelt out and possibly requests can directly be made online through a web-form, and a credit card payment facility of eventual fees is made available.

2.2.4 Statistical Unit

If the unit is “individual”, only one person is going to be interviewed unless he is considered as person-contact for his household, but if the unit is “household”, one or more person could participate. The main body involved in the survey usually decides the statistical unit. The sampling unit that is required to provide the necessary information at the level of detail that is needed for the proposed analyses.

2.2.4.1 Statistical Unit in European countries

More or less, half of countries take the household as statistical unit and the other half take individuals. There are four different cases:

- Statistical unit: household, all members. (Belgium, Great Britain, Israel)
- Statistical unit: household, only an individual selected asked. (France, Spain, Switzerland)
- Statistical unit: Individual, all household members asked. (Germany)
- Statistical unit: Individual, selected individual asked. (Denmark, Finland, Italy, Netherlands, Sweden, Norway)

The country has to choose his statistical unit according to the sample frame, which is used. But it can choose to ask all members or some members of the household or only an individual selected.

Some constraints that may lead to the refusal of the survey have to be taken into account:

- Surveying all members of the household could take too much time
- Not all members could be present
- Not all members of a household would participate in survey
- Parents do not want their children to participate

See Appendix B: Statistical Unit of NTS in European Countries.

2.2.5 Household-based survey

Not all countries have the same concept of “household”. There are small nuances between “households” included in the survey. In general, a household is considered a main house in which members live in the greater part of the year and are occupied on a permanent basis. A household in the statistical sense means all the occupants of a dwelling, without these people are necessarily united by kinship (in case of cohabitation, for example): all people living are included. A household may consist of one single person.

In France, the number of main residences and the number of household is identical by definition. University halls residence are included but occasional

housing for professional reasons, second homes (used for the weekends, leisure or holidays, rented to tourists) and vacant housing (housing for sale, for rent, already allotted to a purchaser or a tenant and waiting to be occupied, awaiting death settlement, kept by an employer for the future use of one of his employees, kept vacant and unallocated by the owner). Now, the definition of a household in France is related to share the same budget.

In France, the following individuals are listed ("Certu Standard" Household Travel Survey, February 2009):

- People who live in this housing most of the year, including:
  - Temporarily absent people (holidays, business trips, hospitalisation for less than one month, etc.),
  - Infants, even if still in the maternity hospital,
  - Subtenants and joint tenants occupying part of the housing;
- People living in this housing for their studies;
- Domestic employees, staff and au pair girls who live in this housing;
- Minors placed elsewhere for their studies and for whom this housing is the family home;
- Couples who have another residence for professional reasons and who come back to live in this housing at weekends, for holidays, etc;
- Minors who live in this housing for their studies and whose parents live elsewhere;
- Couples who live in this housing for professional reasons and who go back to their family home at the weekend.

In Great Britain, a household consists of one or more people who have the sampled address as their only or main residence and who either share at least one main meal a day or share the living accommodation.

In Belgium and Spain, a household is a main house without these people are necessarily united by kinship but collective household are excluded.

In Germany, sample for MOP is done by Random Digit Dialling. For MiD, sampling units are individuals aged 14 years and over out of official registry of inhabitants. After recruitment of these individuals, all members of the respective households are surveyed (including all persons aged 0 and over). A household will be retained within the dataset, if at least 50% of household members responded to questionnaires (person and trip level).

In Italy, even more relevant: AUDIMOB is a personal rather than a household travel survey and only one respondent is questioned, so the definition of household seems not relevant. About individuals who are excluded, individuals in institutions are usually not included.

In Denmark, Sweden, Norway, Finland, Israel and the Netherlands, the respondents are individuals who are sampled. The definition of households and/or family in only used as background information. In Denmark, there are no

exclusions: Every resident person (10-84 years) is part of the survey population, but the response rate is low among people in institutions and people unable to understand Danish or English. The household definition is: “Every person with (exactly) the same address”. “Same address” includes room numbers in institutions, student hostels and the like. Thus, students on hostels are counted as a series of one/two person households.

In Norway people in institutions are not sampled.

In Sweden, children from divorced couples belong to 2 different households even if they don’t live there all the time. In Belgium they belong only where they live when the travel diary was filled in.

In Israel, an individual belongs to a household if he sleeps at least three times per week.

In order to harmonize, a household will be considering as a main house or apartment where inhabitants, with or without family union, live permanently and share the same budget. Institutions and collective household are excluded. An institution or collective household is considering like a house designed to be inhabited by a group, i.e. a group of persons subject to a common authority or not based on family ties or coexistence. Each unit in these collective households should be considered as individual households. Housing development may occupy only a part of a building or, more often, all the same. It includes convents, barracks, nursing homes, dormitories or resident’s halls, hospitals, prisons, hotels and hostels.

2.2.6 Person-based surveys

A person is considered like an individual living in a household but not all household members are considered like acceptable for the surveys. The concept of individual suitable for the survey is mostly different between countries. If the household is made up of only one person, it is this person who answers the questions. These differences are based on the age of the individual, nationality, and language.

In Denmark, the survey relies on the CPR (Personal Identification Number) definition on resident persons. This implies, that any person is included, if he/she has a permanent address in Denmark for more than 3 months.

In Austria, only Austrian people can be part of national travel surveys.

In Luxembourg questionnaires will probably be also in English and Portuguese (in addition to French, German and Luxembourg’s).

In Germany in 2008 MID, survey respondents have to have sufficient language skills (German); questionnaires and interviews were available in German only. In 2002 MID, a Turkish translation was available in principle, but was not used owing to a lack of demand by respondents.

Table 2.2: Minimum and maximum age of individuals in HTS in Europe

Country	Minimum age	Maximum age
Austria	6	None
Belgium	5	None
Denmark	10	84
Finland	6	None
France	6	None
Germany	10 for MOP None for MID	None
Italy	14	80
Spain	None*	None
Sweden	6	84
Great Britain	None	None
Israel	8	None
Norway	13	None
Switzerland	6	None

Source: Shanti Wiki

* In Spain, an adult aged above 18 years old could help to answer children less than 14 years old.

In Sweden the experience with children aged of 6 years is really good. Young people are needed for travel behaviour and measuring how it evolves.

In Norway, specifics survey for young kids are realized, there is more activities survey.

Conditions on age exist at the time of the choice of individual respondents, especially among children and, in some cases, the elderly. When a condition is raised, the minimum age is never less than 5 years (because the younger are not independent for the trips for trip making) and can vary by 5, 6 or more. It's important to ask children (over 8-9) because they usually have a daily mobility on their own: school bus, bikes, walking, and car with parents. This kind of mobility is important in peak hours.

Less common are age limits for seniors like in Denmark, Italy and Sweden.

In Germany, in principle all members of the households are included. In the MOP the socio-demographic data of children younger than 10 are surveyed but they don't fill in a travel diary. If a household has more than five members only the five oldest members report in the survey. In MiD, if the household interview was conducted as CATI, up to 8 household members were interviewed and if the household used the PAPI, only up to 6 household members were interviewed, beginning with the oldest person and youngest are excluded; children younger than 10 years old: in any case proxy interview with parents; children aged 10 to 13: interview in person or as proxy (to be decided by parents); children aged 14 and over and adults: interview in person or as proxy interview.

There are not available reports about specifications of others countries.

Language could also have been a problem so there must be questionnaires in English and in dialects widely used to share the questionnaire in the official languages of the country.

It is recommended to include all individuals regardless of their nationality and the kind of household they living in.

2.2.7 Household or person?

The sampling unit is hard to define and each country has liberty to decide. Some countries interview only an individual but others ask all members of a household.

The good side of asking for interview with all members of a household is that you are able afterwards to analyse how the household members interact and how they e.g. share the car/cars. Ideally you will be able to analyse the travels of the car fleet if you manage to survey all adults.

The bad side of a household survey is that is not easy to get contact to everybody in a household and interview them about the same day (or week). This is resulting in a low response rate if a household is left out if only one member is not interviewed. And especially the response rate is biased to smaller households. If households with less than all members are interviewed it is not possible to get the desired information for interactions between the individuals.

The good side of an individual based survey is a more representative sample for which it is also easier to up weight the responses to the full population.

The choice of household or individual based survey should also consider the decided survey method.

In any case to consider certain aspect:

- Asking all members of the household: the survey will be very long and might result in biased results or response rate due to fatigue of the household. There could be problems of availability of all members and the rate of non-response can therefore increase. The response rate will be related to the household size.
- It is not possible to ask more than two individuals in a phone survey.
- It is interesting to evaluate small children's mobility, what can easier be done in a household survey.
- Caution: survey minors without an adult present is not acceptable. (ESOMAR, article 8)

2.3 Different surveys instruments that co-exist

In Europe, each country uses a different type of National Travel Survey. Note that the main objective of NTSs is to picture the mobility of the nation. Whatever

methodology used and people surveyed, the information acquired has to be the same: personal and household information, vehicle information, daily mobility of an individual, long-distance mobility of an individual of household.

The data collection methodology by face-to-face, by telephone, or by letter resulting in a paper and pencil or a web interview is different from country to country and described later. Several countries combine the methods and in some cases, the method has changed with the experience over the years. For example:

- Addition of the web survey to the telephone interview in Denmark since 2006.
- Change: postal questionnaire to phone survey in Finland, Germany (still available in PAPI and CAWI for MID 2008), Switzerland.
- In Netherlands change from household to individual

2.3.1 Survey methods

There exist personal interviews: phone and face-to-face; and non-personal interviews: postal and mail and web interview. It is possible to make a combination of survey instruments. The basic survey methods are more and more often used in combination with one another to try to capture the benefits of more than one method. For instance, the most common approaches for conducting household travel/activity surveys combine telephone and mail survey techniques.

2.3.2 Face-to-face interview

Respondents are contacted and interviewed about their past travel. The first step in the personally administered survey field process is to contact the respondent. After the interviewer introduces the survey, the respondent can choose: respond or refusal.

Advantages of face-to-face interview:

- Probably the most effective way for enlisting respondent cooperation
- Interviewer may help the respondent to answer, if the interviewee have doubts or don’t understand the question
- Visual cues or aids can be used
- Can easily be combined with a self-administrated section of the survey
- The best method for developing a rapport with respondent and to build respondent confidence
- Long and very detailed interviews are possible.

Disadvantages of face-to-face interview:

- Survey cost is higher than for other methods
- More labour-intensive
- Required a trained staff of interviewers that is geographically nearby
- Fieldwork could take longer than with other methods (phone)

- Method is the most susceptible to disruptions and to crime problems.

Responses facilitators:

- Select interviewers that are of the same age groups, races, ethnic backgrounds, and social classes of potential respondents
- Provide reassurances of anonymity at the beginning of the interview
- Provide descriptions of the importance of the survey and of the specific respondent's role in the survey
- Provide a toll-free telephone number for respondents to call in case they have questions or complaints.

Face-to-face interviews are used in Great Britain and France and in the Netherlands as follow up for respondents, which cannot be contacted by telephone.

2.3.3 Telephone surveys

In the past 20 years, the telephone interview survey has become an extremely popular surveying tool, both for transportation surveys and for other types, as well. As the cost of survey fieldwork has risen, telephone surveys have become more cost-effective than traditional in-home interviews. Telephone interviewers can contact several households in the time it takes a field interviewer to travel to one particular home, and telephone interviewers can be supervised much more effectively than field interviewers.

Telephone surveys are limited in that only households with listed telephones can be contacted. Households without phones are more likely to be composed of ethnic minorities, be poorer, and have lower auto ownership rates than households with phones (Cohen et al., 1993). Since such households are likely to make fewer trips and are less likely to use an automobile for trips, telephone surveys may bias survey results to some degree. Additionally, in recent years there has been an increased prevalence in cellular telephone used but now there is probably a backward movement due to boxes. Many households have chosen to not have a landline telephone, but prefer using their cellular as their primary source of telephone communication. As cellular telephone numbers are not as yet widely available in public directories in most part of the countries (excepted Finland), this trend raises additional questions about the validity of phone surveys and the potential for leaving out segments of the population. Cellphones segment is higher in the younger generation resulting in other biases, which has to be taken care of.

In some countries like Denmark and Finland telephone interview via cell/mobile phones as well are done and therefore people are contacted directly on their cellular phones because a telephone directory for all kind of telephones has been unified. For example in Finland, approximately 93 percent of households have telephones, but this percentage varies from city to city.

There are ways to address the potential bias resulting from non-telephone households. If they can be identified, households without phones can be

interviewed in person. Alternately, households, which share demographic or other characteristics with non-telephone households, can be over-sampled. The U.S. Census Public Use Microdata Sample (PUMS) can be used to identify these characteristics.

There are three types of telephone surveys. In the first, a sample of telephone numbers is drawn from available telephone number lists (either published directories or lists from previous survey efforts). This method is used in Italy. In the second type, the sample of numbers is drawn from a random list of numbers. This is known as a random-digit-dialling (RDD) survey (Travel Survey Manual, chapter 3). Germany uses it to realize his survey in MOP. Finally, the sample is drawn from the National population register, after this the telephone number for the selected person is looked up from the telephone directory. This method is used for more of the European NTS.

It is recommended that all travel surveys be conducted from centralized locations with supervisors in order to ensure they are following procedures correctly. This system allows respondents to speak to a supervisor to verify the authenticity of the survey or to complain. The centralization also allows the stabilization of interviewing hours to avoid respondents contacted too late at night.

Advantages of phone survey:

- Lower cost than face-to-face interviews
- Opportunity to explain the study and answer questions about the survey
- Good method to asking batteries of similar questions and questions with long or complex response categories to be avoided
- Respondents feel more anonymous than for face-to-face
- Respondents can be asked to provide thoughtful and detailed responses.

Disadvantages of phones survey:

- Excellent questionnaire is required
- Requires interviewers to have good reading and writing skills
- Respondents have to take time which is known not to be the case so questionnaires are answered less thoroughly than for other medias
- Survey cannot be too long (maximum 30 minutes)
- There are less flexible terms of content. Questions with long or complex response categories are better to face-to-face.

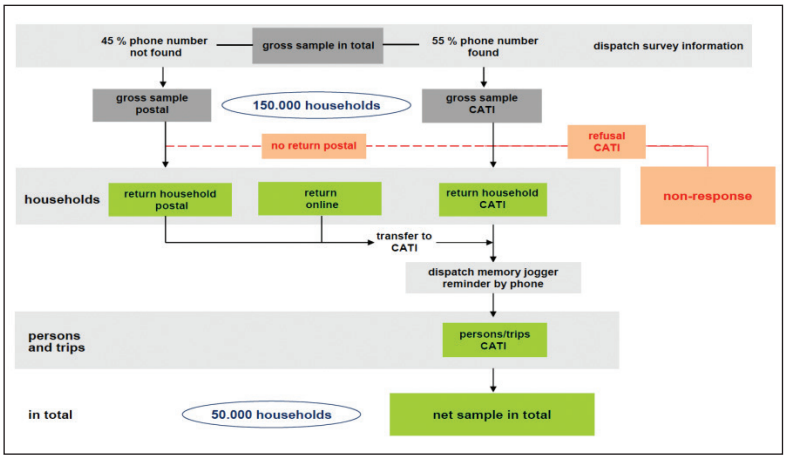
Responses facilitators:

- Make sure interviewers have local accents or are relatively accent-free
- Provide reassurances of anonymity at the beginning of the call
- Provide descriptions of the importance of the survey and of the specific respondent's role in the survey
- Provide a toll-free telephone number for respondents to call in case they have questions or complaints.

2.3.4 Postal surveys

Postal surveys are less used because of a very low response rate. E-mail surveys are going to take the place of this type of surveys. There is not personal contact with respondent, which causes a lack of confidence, and it is very easy for the respondent not read the letter. Postal way is used by countries to send an official notification of the survey in order to advice households and individuals. Sometimes it is also used as a reminder or takes part of a survey combination. The last one is the German MID survey in 2008 where a methodological mix of postal (if no telephone number was available there was a postal contact. All persons had been surveyed by phone or web) and telephone and online survey was used.

Figure 2.2: Two-stage survey in Germany, MID in 2008



Source: Infas. 2007

The main method is phone survey and additional web but with the postal survey, Germans recover some of non-respondent.

2.3.5 E-mail and web surveys

Popularisation of Internet leads to a new kind of survey. These new surveys are called internet-based survey and it can distinguish two different methods: e-mail surveys and web surveys.

Internet-based surveys are commonly used for travel surveys because of their very low cost and resource requirements; and because of their simplicity. A mail survey in its most simple form requires obtaining a complete address list from a source. This can be a sample from the national population register; a public addresses list or the survey's company customer database. The survey company simply send a letter to the household and ask the same or certain person to log into the Internet and answer the self-administered surveys to the households. When this is done, simply wait for replies. Travel surveyors have found that response

levels can be enhanced through the use of pre-notification letters and follow-up letters and questionnaires.

A web-survey allows the surveyed some freedom to respond to the survey that a face-to-face or phone interviews limit. Web surveys are supported thanks to CAWI, new software adapted to this kind of survey.

Advantages of internet-based surveys:

- Low cost
- Easy to present visual aids
- Respondents feel more anonymous and answered more frankly
- Respondents can use more time on finding the correct answer and give more details, e.g. more trips are remembered
- Minimal staff and facilities requirements
- Provide access to the widest sample population
- Respondents can be asked to provide thoughtful and detailed responses.

Disadvantages of Internet surveys:

- Very high non-responses rates
- Respondents need to have access to a computer that could be a biased
- Response rate are biased against less elderly people and youngsters in their 20'ies, less poorer and unskilled workers, but more children
- Excellent questionnaire design is required
- Requires respondents to have good reading and writing skills
- No opportunity to prove or clarify responses
- Data editing task could be substantial especially if detailed address information is required
- Timeliness respondents often forget to complete and return forms for some time after the survey can be completed
- Reminders and follow-ups extend the survey period even further
- Representativeness of the respondent sample.

Specific to e-mail surveys:

- Need for good mailing addresses

Responses facilitators:

- Include a cover letter signed by a high-ranking and popular elected official.
- Personalize the survey materials for each respondent, where possible.
- Use postage stamps on any packages sent to respondents, rather than prepaid or machine stamped mailings, so the mailing stands out from direct mail.
- Send materials in distinctive envelopes.
- Provide a toll-free telephone number for respondents to call in case they have questions or complaints.
- Have the return address (es) be within the region under study.
- Have the return address (es) be for the agency or another public organization, rather than for a private firm.

- Provide the respondent with a deadline for replying to the survey.
- Provide brief reassurances of anonymity on the survey materials.
- Provide descriptions on the survey materials of the importance of the survey and of the specific respondent's role in the survey.

Since 2005, almost all larger European countries have realized one NTS in order to obtain travel description of their citizens. The first NTS were postal or face-to-face survey but the latest follow the phone method combined sometimes with postal, mailing or web services.

In Denmark from 2006 and the Netherlands from 2010 web interviews are combined with telephone interviews. The respondents are contacted by letter and asked to log on the web to answer to the survey. If the answers are not received after a certain period they are contacted by telephone for a phone interview. The combination increases the quality of the survey because the combined mode makes it possible to get responses from a broader part of the sampled respondents and the web respondents are answering more thoroughly and therefore includes more trips under 20 km in the survey (Christensen, 2013). Furthermore, it saves costs related to a telephone only interview.

2.3.6 Using technology in travel surveys

Utilization of CAPI, CATI and CAWI systems are increasingly common. The common sampling method is stratification and the usual sample frame is a census or address directory. In order to minimize the effect of non-response, most of European countries used a weighting process to balance the sample. A common feature is also, that people in institutions are generally excluded from NTS.

2.4 Computer-Assisted Interviews and integration of new technologies

Travel Surveys are designed to be highly structured. Typically, interviewers have a questionnaires or discussion guides and recording their interviews in order to analyse the responses at a later date (Jones, 1985). The most common technique used to record results in face-to-face and phone interviews is PAPI (Pencil and Pen Interview). The widespread availability of laptop and notebook computers has led to the development and wide acceptance of computer-assisted telephone interviewing (CATI) and computer-assisted personal interviewing (CAPI) software in order to minimize the errors in coding or entering data codes in a data file.

2.4.1 C.AT.I. (Computer-Assisted Telephone Interviews)

CATI is a telephone survey technique in which the interview is realized with the help of a software application. The software allows a continuous flow of the questionnaire depending on the responses of the respondent, with a

structured system of microdata collection by telephone that speeds up the collection and editing of microdata; it also permits the interviewer to educate the respondents on the importance of timely and accurate data (BLS Information. Glossary U.S. Bureau of Labor Statistics Division of Information Services. February 28, 2008).

Table 2.3: CATI advantages and disadvantage

CATI Advantages	CATI Disadvantages
Permit the entry of only legal codes in any particular field	Great deal of timeout. Interviewers will not generally be able to fix them as they go along: Testing and debugging complex CATI programs could take several weeks and require well over a person-month to complete.
Preventing data inconsistencies	Cannot control the quality of data entry
Ensuring that respondents are asked all the relevant questions and are not asked ones that should be skipped	Difficult for interviewers to include special notes or extra information.
Use information from previous questions or previous interviews to make interview questions to a particular respondent	Can take longer than a pencil-and-paper interview.
Help combine the survey's data collection and management functions	Highly specialized software routines: need to enlist marketing research contractors for the survey effort
Sample management	
Sets the priority sequence and timing of calls	
Reproduce any interview in supervisor screen (audio monitoring)	
Stores information on on-line calls and printed records	

The interviewer read the questions that the software proposes to the respondent and records the answers. The software allows the correction immediately when the data are collected. The program will personalize questions and control for logically incorrect answers. The software itself dials the contact.

It is possible to combine CATI and PAPI techniques within the same survey effort. Some recent household travel/activity surveys have used CATI techniques for recruitment, but PAPI techniques for data retrieval. It is also possible to combine the techniques within the same survey, such as by using CATI to retrieve household and person record information and PAPI to collect trip and activity diary information.

2.4.2 C.AP.I. (Computer-Assisted Personal Interviews)

CAPI is a face-to-face interview tool that consists in a portable computer equipped with software that allows data collection during the personal interview. This technique is similar to CATI but a visual support can be offered. There is no need to transcribe the results into a computer form. The computer program can be constructed so as to place the results directly in a format that can be read by statistical analysis programs. If the interviewer is not present, the respondent can use CASI (Computer-Assisted Self Interview) where the subject answer questions by him thanks to the software. This program can be placed on a web site, potentially attracting a worldwide audience.

2.4.3 C.AW.I (Computer-Assisted Web Interviews)

CAWI is an Internet surveying technique in which the interviewee follows a script provided in a website. The questionnaires are made in a program for creating web interviews. The program allows for the questionnaire to contain pictures, audio and video clips, and links to different web pages, etc. The website is able to customize the flow of the questionnaire based on the answers provided, as well as information already known about the participant. It's considered to be a cheaper way of surveying since you don't need an interviewer unlike Computer-assisted telephone interviewing. With the increasing use of the Internet, online questionnaires have become a popular way of collecting information. The design of an online questionnaire often has an effect on the quality of data gathered. There are many factors in designing an online questionnaire; guidelines, available question formats, administration, quality and ethic issues should be reviewed.

Table 2.4: Advantages and disadvantages of CAWI

Advantages	Disadvantages
Greater flexibility in questions	Questionnaire has to be excellent to avoid misunderstandings
More quickly to respondent	Not everyone has access to the Internet, so the response rate is limited
Flexible schedule	Lack of confidence
Cheaper: no costs associated with purchasing paper or other materials for printing. Postage costs are also mitigated.	Young people are usually respondent
Easier to correct errors on an online questionnaire	Pure Web surveys typically have very low response rates, and can be very biased in terms of self-selection and inability-to-respond.

2.4.4 Use of GPS in travel surveys

The use of GPS devices in travel survey is interesting to collect data on sub-samples of households. The capacity of these devices for providing very precise information about locations, routes, times, distances and traffic of travel is the main reason to experiment it.

GPS devices could be given to respondent of survey or could be vehicle-based. Both possibilities are included in a travel diary.

In France, for this first experimental attempt, it has been authorized by the French National Commission for Data protection and the Liberties (CNIL) under the condition, that the GPS component should concern only volunteers. In the French experience approximately 800 volunteers accepted to carry a GPS receiver. When a respondent agrees with the GPS option:

- At the first face-to-face interview, the interviewer gives the "GPS Pack" to the respondent (older than 17) and explains how to use the equipment;
- Between the two visits, the respondent will travel and the unit will record trips;
- At the second face-to-face interview:
- The respondent gives back the "GPS Pack" to the interviewer;
- Immediately the interviewer downloads the GPS data on his laptop computer using a Bluetooth transfer, for a brief additional interview;
- The interviewer checks the GPS unit, reloads it; the equipment is ready for a new interview.

In Israel, in the Pilot Survey, three methods were tested, based on previous experience that determines it is necessary to perform at least one personal visit to the household.

- CAPI+ 2 visits (recruit + retrieval), with or without GPS
- 1 visit to recruit + CATI to retrieval
- 1 visit to recruit + CAWI to retrieval

Table 2.5: Response rates results of Pilot Survey in Israel

	Fully answered by all members	Fully answered by most members	Partially answered	Total
2 Visits - No GPS	78%	9%	13%	100%
2 Visits - With GPS	74%	8%	18%	100%
Recruit + CATI	54%	9%	36%	100%
Recruit + CAWI	27%	3%	70%	100%
Total	60%	8%	33%	100%

Source: Shanti meeting in Eindhoven. WG1

The results of the Pilot Survey show that a 2 visits method increases the response rate. GPS is not a tool that will enhance response rates but certainly it will improve data quality.

In Great Britain, during 2011 NTS, a GPS pilot survey has been conducted in order to compare its results with those obtained from the travel diary data collected by the main NTS for the same fieldwork period.

The GPS data were collected for 874 respondents aged 12 or more during the seven day travel week that followed the NTS pilot survey, alongside additional information collected during the CAPI placement and pick-up interviews to assist data processing.

There are a number of disparities between the GPS personal travel data and the data from the NTS diary that are collected in the analysis report (British National Travel Survey analysis Report).

Clearly there is potential for defining standardized procedures and providing guidance on a number of aspects of such surveys. This includes sample sizes and methods of drawing samples, geographic and socio-demographic distribution of the sample, the number of days for which GPS data should be collected, minimum hardware specifications for the GPS devices, the use of incentives, methods for deployment of the devices, methods of return of the devices, etc. However, at this time, it is probably too early in the development of such surveys, and there is too little experience to define standardized procedures. Therefore, this is an area that should be considered as being currently out of scope, but necessary to add within the next surveys. It also may require extensive field experimentation to develop good standardized procedures through comparative studies that clearly show which are the preferred methods. Also, as personal GPS devices (as opposed to in-vehicle GPS devices) become more practicable and available, the nature of the survey may change quite rapidly (Travel Manual Survey, chapter 14).

The interest is not only about what kind of survey to use but also the process of sampling and weighting. Another expectation required is how to treat non-response in order to enhance responses rate. See Appendix A: Survey method of NTS in European Countries.

2.5 Questionnaires and Travel Diaries

2.5.1 Questionnaires

There is a lot of kind of questionnaires and all of them are different depending on the purpose. This tool is very delicate and should result in excellence. In postal and mail surveys, questionnaire is the link between survey's organization and respondents, so every questions, every concept has to be clear in order, that respondent don't leave the survey.

A travel survey is composed of a set of questionnaires depending on the objective of the survey. In chapter 6 of this rapport, there is a proposition of the minimum of questions to ask in travel survey.

The questionnaire has to be referring to: household information, individual information, vehicle information, travel information, and possibly opinion.

- Household card, relating to the characteristics of the household and of the residence;

- Person card, which primarily contains questions about the socio-economic characteristics of each person;
- Travel card, which counts describes all travelling done on the day before the survey day;
- And possibly opinion card, to be completed, by only one person drawn at random in the household

2.5.2 Travel Diaries

The travel diary is a central data source for the understanding and measurement of the travel behaviour of individuals and households and therefore essential to the comprehensive planning and monitoring of transport policy, operations and infrastructure.

Table 2.6: Type of questionnaire of daily mobility and long-distance in the last NTS of European countries

Country	Type of questionnaire in daily mobility	Type of questionnaires in long-distance trips
Belgium	Diary for a pre-defined day	By memory – full description of LAST long-distance trip
Denmark	Trip of the day before. The survey day is predefined	Trips of the day before
Finland	Trips of a specific predefined day. Telephone interview with memory jogger, a simplified trip diary form sent in advance	Telephone interview with memory jogger, a simplified trip diary form sent before survey
France	Trips of the day before and of the last week end day by memory	3 months by memory + 3 months self administered with memory jogger.
Germany	MID: CATI based on memory jogger MOP: paper and pencil trip diary for 7 days a week	MID: CATI based on memory jogger
Italy	Trips of the day before and of the last week end day by memory	
Netherlands	Diary for a pre-defined day	
Spain	Week day before + 1 weekend day by memory	Data collection by memory
Sweden	Memory collection with memory jogger sent in advance	Data collection with memory jogger
Great Britain	7-day diary previous to the first visit + face-to-face questionnaire	By memory retrospectively + 7-day diary
Israel	Memory jogger for the day before, travel diary + GPS for survey period	Data collection by memory
Norway	Trips on a specified day	Collection by memory (diary provided in the advance letter)
Switzerland	Stage diary	Data collection by memory

The travel diary is a survey instrument designed to record all movements of a person over a given period of time with all relevant details for the relevant analyses and the eventual modelling time horizon. It will consider travel and non-travel as two distinct classes of activities.

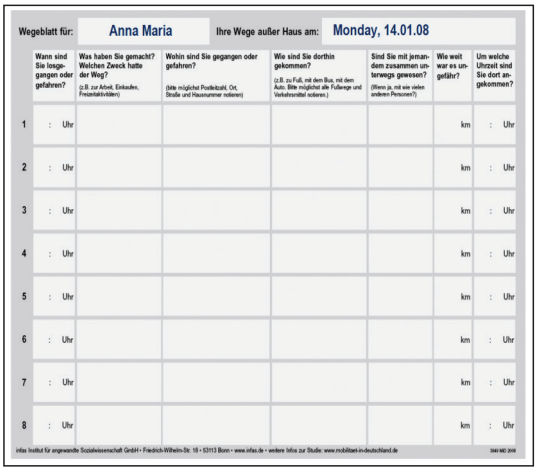
It consists of (K W Axhausen. June 1995):

- The diary proper recording all movements sequentially during a specific period of time
- The person instrument recording person specific information
- The household instrument recording relevant household based information
- The resource instrument recording the relevant details about the physical and social means available to the household. Examples are cars and other motor vehicles, bicycles, public transport season tickets, telephones, telemetric equipment etc.

Travel Diaries are usually focused on daily mobility. In the next table, the questionnaires used in European NTS for their last survey is defined

A travel diary memory jogger is commonly used. Belgium, Germany, Israel and Switzerland used it in the questionnaire of daily mobility and Norway in long-distance trip questionnaire. Finland, Sweden and Great Britain use it for both kinds of questionnaires.

Figure 2.3: Memory Jogger used in Germany (MiD) for daily mobility



Wegeblatt für: Anna Maria — Ihre Wege außer Haus am: Monday, 14.01.08

	Wann sind Sie losgegangen oder gefahren?	Was haben Sie gemacht? Welchen Zweck hatte der Weg? (z.B. zur Arbeit, Einkaufen, Freizeitaktivitäten)	Wohin sind Sie gegangen oder gefahren? (bitte möglichst Postleitzahl, Ort, Straße und Hausnummer notieren)	Wie sind Sie dorthin gekommen? (z.B. zu Fuß, mit dem Bus, mit dem Auto. Bitte möglichst alle Fußwege und Verkehrsmittel notieren.)	Sind Sie mit jemandem zusammen unterwegs gewesen? (Wenn ja, mit wie vielen anderen Personen?)	Wie weit war es ungefähr?	Um welche Uhrzeit sind Sie dort angekommen?
1	: Uhr					km	: Uhr
2	: Uhr					km	: Uhr
3	: Uhr					km	: Uhr
4	: Uhr					km	: Uhr
5	: Uhr					km	: Uhr
6	: Uhr					km	: Uhr
7	: Uhr					km	: Uhr
8	: Uhr					km	: Uhr

infas Institut für angewandte Sozialwissenschaft GmbH • Friedrich-Wilhelm-Str. 18 • 53113 Bonn • www.infas.de • weitere Infos zur Studie: www.mobilitaet-in-deutschland.de

Source: Infas. 2007.

2.5.3 The main definition

A travel is a movement of a person from the place of origin to a destination made for a stay or a reason, it is a general term and not used as a definition in a NTS.

An activity is the main business carried out in one spatial. It includes any waiting time before the start of the activity. Note that walking or riding could be a purpose or an activity additional to be part of a movement.

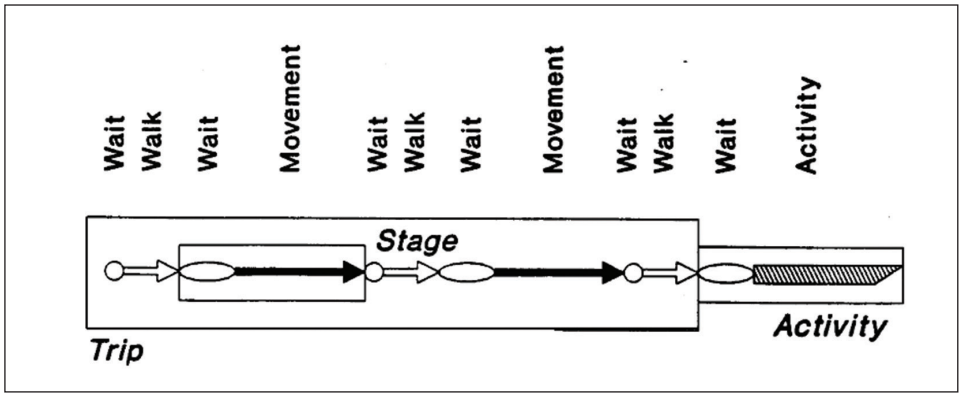
The basic unit of travel, a trip, is defined as a one-way course of travel with a single main stay or activity. A trip is a sequence of one or more stages between two activities using the public domain.

A stage is a continuous movement with one mode including any waiting time before the start or during the movement. A new purpose involves a new stage even a new trip.

Changing mode or even changing vehicle means a new stage.

A tour is a sequence of trips starting and ending at the same location. If the tour starts and ends at home, it is called a journey mainly in long-distance.

Figure 2.4: Elements of the movement/activity chain



Source: Travel Diaries, an annotated catalogue. K W Axhausen

The objective of the survey should be to study mobility throughout the country independently where they occur stage or trip.

Trips may include more than one mode of transport, and each mode is recorded as a stage within that trip. When ‘main mode’ is used in the title of a table or charts this allocates information for the whole trip according to the mode used for the greatest length (in distance) of the trip. When ‘mode’ is used this refers to information for individual stages of trips. Mode of transports: walking, roller, bike, motorcycle, motorbike, car, caravan, bus, rail, and plane. If we travel with same mode but we change vehicle is a new stage because we stop.

In each country it exist a different criteria. If we do not known distance of each stage, main mode is based on hierarchy on modes. The respondent determines Finland main mode.

Carpooling is becoming more and more practicing and it could be good to think how carpooling behaviours in travel surveys measure.

Some stages are excluded in some countries. In Spain and Italy, walks of less than 5 minutes are excluded. In Denmark walks less than 50 m excluded if linked with other modes.

The items related to movement can be grouped as follows:

- Time and space
- Modal detail
- Information use
- Company and situational handicaps
- Parallel activity.

The definition of the trip and its measurement vary from one country to each other. For Finland, France, Norway and Spain, a trip is a movement from one address to another for a purpose. Some countries add boundaries and is not a stage-based but activity-based where the activity of each trip is the principal control fitment.

Table 2.7: Trips in latest NTS

Country	Distance limit for trip	Collection of stages	Trip-based / activity-based
Belgium	No	Yes	Activity-based (?)
Denmark	No	Yes	Trip-based
Finland	No	Yes	Trip-based
France	No	No, but multiple modes are identified	Trip-based
Germany	No	No, but multiple modes are identified	Trip-based (MID)
Italy	>5min for walking trips; <20 km Trips >20 km are not included	No	Trip-based
Netherlands	No	Yes	Trip-based
Spain	Daily mobility; > 5 min for walk trip	Yes (daily mobility)	Trip-based
Sweden	No	Yes	Stage-based
Great Britain	Walk trips <1mile (but > 50 yards) only on day 7	Yes	Stage/trip based
Israel	> 100 Meters	Yes	Activity-based
Norway	No	No, but all transport modes are recorded	Trip-based
Switzerland	> 25 meters (for a stage)	Yes	Stage-based

In Sweden is a transport between two places where the respondent performs errands; in Denmark is a movement from one stay to another on public space; in Germany is a movement from one activity to another, in Great Britain is one-way travel having a single main purpose; in Netherlands is a journey between two activities; in Belgium is a one way movement on a public street between an origin and a destination for a single purpose; in Switzerland is a one or several stages and is defined by the trip purpose and in Israel is a movement from origin to destination that are more than 100 meters apart. In the next table are described the trips taken into account in NTSs.

2.5.3.1 Daily Mobility

All NTS ask about daily mobility. It is one of the main purposes of the surveys. The instruments used in order to ask about daily mobility (questionnaires, travel diaries, etc.) will be described in a further chapter.

2.5.3.2 Long-distance mobility

Long distance mobility of each country is in Table 2.8

Table 2.8: Definition of long distance travel in European National Travel Surveys

Country	Definition of long-distance trip in last survey
Belgium	> 100 km (for 1way trip) but without commuting trips (even if longer than 100 km) Distinguishing long-distance trips to abroad and other ones
Denmark	No specific definition: trips are reported regardless of their length. In 2010-11 a special survey was conducted on overnight trips.
Finland	> 100 km
France	> 80 km fly distance" 100 km on network
Germany	MID: at least one overnight stay MOP: no distance travel analysis
Italy	No distinction
Netherlands	No specific definition
Spain	>=50 km or < 50 km + one overnight stay
Sweden	>100 km
Great Britain	50 miles or more (80 km) within GB
Israel	> 50 km
Norway	≥ 100 km fly distance
Switzerland	Excursions: trips longer than 3 hours and not daily trips Long distance: journey with at least one overnight stay

At the beginning of the history of NTS, not all the countries asked about long-distance travel but since the year 2000 all the countries except Netherlands and MOP in Germany also Italy if trips > 50 km are really excluded includes this

chapter on their process and have a specific questionnaire to long-distance travel. Usually, each country has a different definition of long-distance travel.

In Italy, there is no formal distinction between short distance and long distance trips in the planning of the questionnaire but the others countries do.

In Denmark, the survey covers all trips without an upper limit. Travels abroad include destination and where it leaves Denmark, but only the distance and travel time in Denmark is included. There is no long distance part, but in 2010-2011 a separate overnight survey was conducted.

EUROSTAT considers that 100 km is the threshold of the long-distance trip.

2.5.4 Geolocalisation and coding in European surveys

Table 2.9: Geolocalisation and coding in latest European surveys

Country	Year	Zoning level (XY, municipality…)	Way of coding locations
Belgium	2009		A posteriori coding
Denmark	From 2006	Coordinates (98% of places), NUTS3, Municipality Code, National Traffic Model zone and more Community zoning	90% based on address search in questionnaire. 8% post process based on respondents descriptions.
Finland	2010-11	Geolocation (address) without *a priori zoning*	A posteriori coding using several geographical data bases
France	2007-08	Community zoning	Municipality coding by CAPI
Germany	2008	MID:address for home and work or education place MOP: no geocoding	Geocoding of HH address and individual place of work/ education (max. level: stretch of road); confirmation of HH address as part of telephone interview MOP: no geocoding
Italy	2000-09	Municipality level	
Netherlands	2010-.	Municipality	Yes *a posteriori?*
Spain	2006-07	Census sections	*A posteriori* community coding
Sweden	2011-2012	Small area market statistics	Real-time coding
Great Britain	2002	Full address + postcode (diary day 7)	A posteriori coding
Israel	2013	Statistical zones	Real-time coding
Norway	2009/10	Geolocation (address) without *a priori zoning*	Real-time coding
Switzerland	2005	Geolocation without *a priori zoning*	Real-time coding with coding of the routing

In Germany, In 2008 MID, the base sample: Geocoding only for the household place of residence and – if applicable – for place of work / apprenticeship at street level (data to be used only to add further spatial variables); regional add-on samples: Geocoding of all trip destinations for selected regions.

2.6 Sampling and weighting methods that co-exists

2.6.1 Sampling frame

A sampling frame provides the means to reach each member of the study population who would be eligible to be surveyed. A potential limitation of a sampling frame is that it may provide only a partially complete list of all eligible sampling units and may thus require to be augmented by additional sources. When two or more data sources need to be combined, care must also be taken to minimize duplicate entries and potential inconsistency that may appear in both sampling frames. However, in travel surveys, sampling frames often do not exist, and would be inordinately expensive to create. In other cases, a multi-stage sampling method may be needed to get around the lack of a complete sampling frame (Travel Survey Manual, chapter 5).

A sampling frame could have different provenances:

- **National Register of Population/ Central Person Register:** Database of population, national level. Each individual is attached to an address and personal information, including household information
- **Census population/ Communal Registration offices:** database of population, municipality level. Each individual is attached to his main address and personals information
- **Address database/ Postcode address file**
- **Telephone Register:** Land-line telephone subscribers and for some countries cellular telephone subscribers
- **R.D.D: Random Digital Dialling:** selected people generating phone numbers at random
- **New dwellings built census:** Data of population living in new built proprieties (France).

In case of a National population register is available this gives the most accurate representative sample even with the lowest cost.

Sampling a population thanks to an official census has some advantages related to the methods mentioned that economy, speed and timeliness, feasibility and quality and accuracy data.

The problem of census, the National Register of population and address database is that in some countries they are not really updated. In Nordic countries the National Register of Population is in real time, a max of 1-week delay! People change their address for a time and do not update the census. If using telephone register, the problem is that some people only have mobile phones; especially young people and these are not in the phones list in some countries.

Another usual problem is privacy. In some countries, people can declare that they are not willing to participate in surveys or others scientific projects, which leads to a biased sample if it is not considered in the sampling process.

R.D.D is a good method to get complete coverage of a geographic area if a person register or a census not exists. It could generate all phone numbers including unlisted numbers. For both, R.D.D and telephone register sample is biased for individuals or households having more than one telephone number in the telephone register because the probability to be sampled is higher for these. The limitation of sampling by R.D.D is furthermore that it does not include households without any phone number. For both person register and census based sampling unlisted telephone numbers is a problem when respondents are contacted by telephone for a CATI. One problem is countries in which the cellular phone numbers are not listed. The increased use of cellular telephones has exacerbated this problem with 12.8 percent of households reported to be cell phone only during the last half of 2006 (Blumberg and Luke 2007). Even when cellular phone numbers are included in the registers unlisted numbers are often a problem due to privacy. In Denmark, more than 10% of a register-based sample has no listed telephone number even when it is known that only few percent of the population has no access to a telephone.

2.6.1.1 Sampling frame in European countries

Table 2.10 shows the sampling frame of each country of the study. Most countries use a national or municipal person register. In those cases, surveys organization can obtain more information about individuals and household that is not easy to obtain with phone or address registers.

Table 2.10: Sample frame in Europeans countries survey

Country	Year	Sampling base
Austria	1995	Selected municipalities, Austrian resident
Belgium	Before 2004	National Register
Denmark	From 1992	National population register
Finland	2004-05	National population register
France	2007-08	Census + new dwelling
Germany	MID: 2002 and 2008	MOP: RDD (Random Digital Dialling); MID: Communal Registration offices
Italy	2000-09	Telephone Register
Netherlands	2010-.	Address database
Spain	2006	Municipal Population Census
Sweden	2011-2012	National population register
Great Britain	1988-2008	Postcode address file
Israel	2013	Addresses from city taxes files
Norway	2009/10	National population register
Switzerland	2010	Census

In Germany, R.D.D is use for a first phone contact for MOP. In the German MiD survey, respondents are sampled from population register. The first contact with the households is via telephone. When no number is found, households are re-contacted by postal with the help of register office's sample.

An important issue in household surveys is the handling of uncompleted households. – If you reject all uncompleted households, you'll get a very low response rate among the largest households. This leads to a discussion on the criteria for 'redeeming' of uncompleted interview – As far, various approaches are used to solve biases for this problem.

2.6.2 Sample Size

The sample size is the number of subjects in a subset of a population selected for analysis. The size of the sample and the way in which it has been drawn from the population are critical issues in any research study. A random procedure is necessary for validity of the study. The sample size that is required to measure the socio-economic characteristics and travel behaviour of the study population in a precise and accurate manner and to provide policy sensitive and statistically robust inputs to modelling.

The sample size that would be required to provide a desired degree of precision under a specific level of statistical confidence for each of the variables of interest; or alternatively the precision or level of confidence that can be expected for each variable of interest by collecting information from a given sample size. The process of determining sample size and relating it to precision and level of confidence can be conducted either for the whole sample or for individual market segments of greater interest. Although the same sampling principles are used in both cases, collecting an adequate sample for different market segments is expected to result in a larger sample size than would be required for the whole sample under the same precision and level of confidence requirements.

2.6.2.1 Sample size in European countries

Between countries, the sample size varies:

– From 15000 to 60000 individuals,
– From 17000 to 32000 households, except for Spain (nearly 50000 households) and Great Britain (about 8000 households).

But in term of mobility, it is more than 50000 trips in Great Britain, because data are collected for a whole week.

Thus, in term of number of trips, which determines the accuracy of data, the sample size varies between 40.000 trips (Italy) and 230.000 (Spain) in daily mobility. For long distance sample size is around 35.000-40.000 trips for long distance

in Spain and Norway. However, cluster effect, due to the description of several days by the same individual, as well as to responses from different members of the same household, have to be taken into account for the calculation of confidence intervals. The expected response rate is also an important parameter for the determination of an acceptable sample size.

2.6.3 Sampling method

Different processes exist to draw the sample with a probabilistic sampling method:

- **Stratified random** (Belgium, Denmark since 2012, Finland, France, Germany, Italy, Netherlands since 2010, Spain, Sweden, Great Britain, Israel, and Switzerland): it consists in segmenting the population in sub-population or strata prior to the sample frame.
- **Uniform random** (Denmark before 2012, Netherlands before 2010, and Norway): sampling units are drawn randomly from the sample frame.. Each element has the same probability of being chosen.
- **Cluster:** Sample of groups is selected and every member of the groups is selected
- **Multi-stage***:* sampling units are groups rather than individual elements. Constructing the clusters is the first stage. Deciding what elements within the cluster to use is the second stage. The technique is used frequently when a complete list of all members of the population does not exist or is inappropriate.
- **Systematic sampling:** items are chosen in a systematic manner (Austria)

Each sampling unit has a non-zero probability of being selected as part of the sample.

In Europe stratified random or uniform random sampling are commonly implemented. The stratification used could be:

- Geographical: region, province (Belgium, Finland France, Germany (also spatial), Italy, Spain, Sweden, Israel, Switzerland, Denmark)
- Household size (Belgium, Spain, Germany)
- Age (Finland, Italy, Israel, Switzerland, Denmark)
- Gender (Finland, Italy, Israel, Switzerland, Denmark)
- Type of household (Germany)
- Car ownership (France)

It could be possible to form a sample with a combination of types of stratification.

This method is useful to study segments of population requiring a greater degree of precision. The homogeneity of each segment reflects the similarity in socio-economic characteristics and travel behaviour of respondents within each segment. Stratified sampling can be used to reduce the amount of data

collection needed by segmenting the survey population into more homogeneous strata and sampling at a higher rate from strata with a higher degree of variability and heterogeneity.

Most countries used a random sampling method with geographical stratification. This process ensures the complete coverage of the country. Usually, territory is divided in sectors as population centres and number of inhabitant in NTS and a minimum of survey are required for each sector. It is also common to mix geographical and socio-economic stratification.

See Appendix C: Sampling in NTS in European Countries.

2.7 Non-response

Non-response is the inability to measure all the units of sample of all variables of interest. Two different types of non-response exist:

- Total non-response: any information about the unit selected other than sample frame
- Partial non-response: unit selected responded only to a part of the survey and not all interesting variables.

The presence of missing data affects the quality of inference in particular because the respondents and non-respondents generally have a different behaviour. Non-response introduces a decrease of accuracy of estimators and a bias to the survey, more or less important depending on whether the behaviour of respondents and non-respondents are more or less different.

When a unit selected does not respond to the survey, sample is smaller; this is translated by a loss of information. So, the reduction of the sample causes accuracy estimator problems. This problem could be corrected thanks to a weighting procedure.

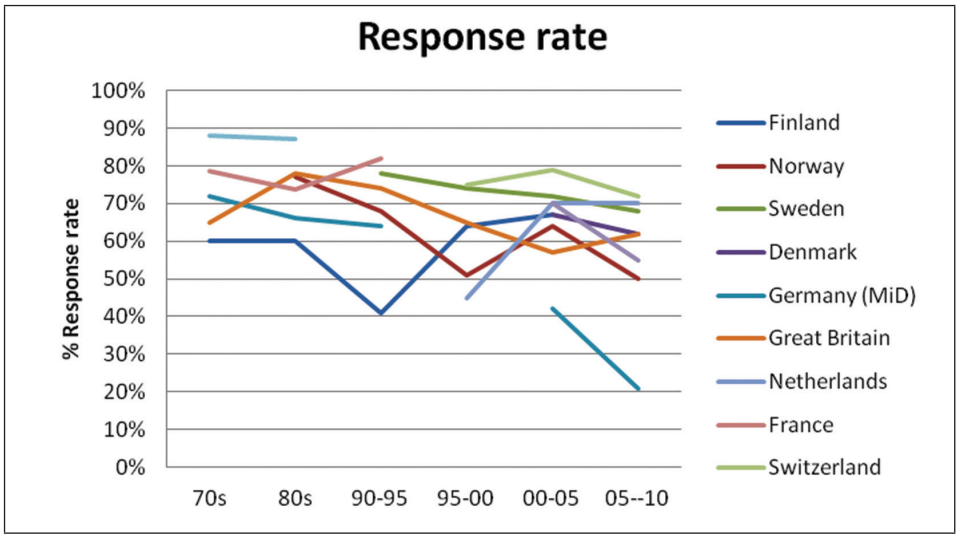
Bias problem is due to behaviour of non-respondents has different characteristics than behaviour of respondents.

In order to limit non-response, it is better to enhance survey procedure and determine some procedures to reduce it. Even if it is reduced, there will be still non-responses, so it is needed to find techniques to correct for it.

2.7.1 Reducing non-response

Non-response could be caused by the failure of potential respondent to reply to the survey as a whole or to respond to particular items on the survey. In the first case, managers must improve survey response with some simple procedures. In the second one, some methods are used to reduce non-response and improve the original response rate.

Figure 2.5: Evolution of response rate in NTS in European countries



As the graphic shows, response rate is decreasing in latest years. In the 90s, the response rate varied between 60% and 70% but now it varies between 50%-70%. There are several reasons for this is so you have to react and find solutions to overcome the lack of response. Possible solutions are to find procedures in methodology, which may limit the non-response.

2.7.1.1 How to limit non-response?

It exist four simple procedures in order to improve survey response:

- Pre-notification: contacting potential respondents by phone, postal letter or mail before the realization of the survey, soliciting participation. It builds respondent interest in the survey effort and helps to allay respondent doubts about the validity of the survey. There is evidence that pre-notification improves survey response rates, response speeds and response quality (Hornik, 1982). In Europe, all the countries send an official letter before the survey. In addition, Norway reported by telephone, Finland attached a simplified trip diary and Israel has made promotions on radio and newspapers. Metropolitan Washington Council of Governments (MWCOG) estimates that the pre-notification letter increased survey participation by between five and ten percent.
- Follow-up with respondents who do not complete the survey: to clarify responses on returned questionnaires and to convert refusals and other non-responses into completed usable responses. Follow-up postcards, a follow-up letter, follow-up mail, new survey material, telephone reminder, telephone retrieval, combination of any of the above, could do it. The best strategy in terms of response rate is pre-notified with two follow-up contacts (Peterson, Albaum and Kerin). Some countries made reminders call, up to

30 for Finland, several for Spain, one reminder call by day for Germany and unlimited for Norway and Sweden; one reminder for British, French and Belgian NTS. Denmark indeed has a reminder system: the entire pattern with repeated telephone attempts is one huge reminder system, although the only way is a phone interview.

- Incentives: sometimes, respondents received some incentives in order to motivate them to participate in the survey. This could be cash, gifts, lottery or charitable contribution in their name. The Danish TU uses incentives for the web-only interview in an attempt to increase the share.
- Response facilitators: mechanism for increasing survey response. Origins are various and depend on the type of survey.

In addition to these procedures, a large number of factors already established in the methodology of conducting the survey, motivate people to participate. Questionnaire design is a bigger step; the goal is to ask questions that will lead to reliable responses and non-refusal on the part of respondents. Surveyors must be well trained and must know the issues and objectives of the survey so that they are able to transmit to respondents. The sample frame has to be defined taking into account the cost of the survey and accuracy.

2.7.1.2 How to correct non-response?

It must be remembered that it exists two types of non-response: total non-response and partial non-response. When questionnaires were completed, the first step is the validation data because an invalid response may become partial non-response.

It exists two methods to correct non-response: weighting and imputation. The method of weighting is useful to correct only total non-response but imputation can be used to correct total and partial non-response.

2.7.2 Weighting methods

Weighting is a factor by which some quantity is multiplied in order to make it comparable with others. Weighting is necessary in surveys if the process is not completely at random. It allows to correct bias related to non-response and out scope problems. In particular, the non-response rates generally increase with the size of the household when the whole household is interviewed, failure to correct the bias which results from this would lead to a significant underestimation of the population of survey area.

The sample simply consists in assigning to each household or individual questioned a weighting coefficient equal to the inverse of the sampling rate per sector.

Sample weighting could be used to accomplish the following objectives:

- To compensate for differential probabilities of selection among subgroups (in stratification procedures, geographical strata, age-gender)

- To reduce the effects arising from non-response
- To compensate for inadequacies in sample frame
- To bring sample data up to the dimension of study population

The weighting methods used by the European countries in NTS (Table 2.11) are:

- Calibration on margins: provide a weight depending on the variables used in stratification and the sample frame of reference. It is the most popular method in NTS. It makes possible to rectify a sample from a survey, by reweighting, using auxiliary information available on a certain number of variables, called calibration variables (size of household, number of cars…).
- Post-stratification: Once settled weights, we developed a new structuring of these for fixed and make them more precise. Some countries added this method to margin calibration. Adjustment involves replacing initial weightings by new weightings such that, for each variable used for calibration, the numbers for the modalities of the variable estimated in the sample after weighting are equal to the numbers known on the population.

Table 2.11: Weighting methods in NTS

Country	Weighting method
Austria	Multi-step weighting procedure for households, persons and trips; population referred to all
Belgium	Margin calibration with national register data
Denmark	Margin calibration with official population statistics, also drawn from CPR. Only age, gender, municipality and day of the week
Finland	Margin calibration and post-stratification with Population Register: municipality group, household size, gender, age group
France	Margin calibration with census + correction for non-response mechanism
Germany	Post-stratification and margin calibration
Italy	Re-proportioned with respect to its reference universe. Weighting variables are gender, age (per year) and region of residence
Netherlands	Calibration with several variables (demographics, spatial, car characteristics, month)
Spain	Municipally census
Sweden	Margin calibration
Great Britain	Calibration weighting
Israel	
Norway	Geographic zones (municipality) and calibration with Population register
Switzerland	Margin calibration with census

- A multi-stage procedure is possible following this approach:

    1. Computation of weights to compensate for unequal probabilities of selection
    2. Adjustment for non-response
    3. Post-stratification of the sample weights to sample frame

Weighting method makes it possible to reduce the variance, and thereby improve the accuracy of the results obtained, and to reduce bias due to total non-response.

In Europe, the method usually required is margin calibration if census and statistical institutes have classifications of the study population according to the variables used in stratification. Usually the variables used are geographical (region, census) and demographic (age and gender). Netherlands is the only country that used external data, in particular: number of vehicles, Car fleet of RDW, demographic data.

2.7.3 Imputation procedure to cope item non-response

Imputation, defined as “the replacement of the missing data by one (or several) given (s) deducted (s) or calculated (s) based on information obtained for the failed unit and / or units that are close to him”, was presented as the most common method used to correct for non-response in activity-travel survey data. The advantage of imputation is that it enables the use of multivariate analysis methods that cannot be applied on data with missing values. The disadvantage is that it may bias the relationship between variables or complicate the calculation of the quadratic error of the corrected variable.

The techniques used to correct the item non-response are usually imputation. Imputation involves replacing missing data by one (or several) given (s) deducted (s) or calculated (s) based on information obtained for the failed unit and / or units that are close to him. It can be inferred:

- Direct calculation from other information on the same unit;
- Formalized relations generally estimated by regression on the complete observations (e.g., speed depending on the distance to impute duration);
- One (or more) “donor(s)”, that is to say one (or several) observation(s) whose characteristics are similar, which is closer to the incomplete observation.

Unit non-response refers to the failure of a unit in the sample frame to participate in the survey. In the context of travel diary surveys, unit non-response can arise for a number of different reasons including refusal, non-contact, infirmity or temporary absence (see, e.g., Brög and Meyburg, 1980 (5); Kim et al., 1993 (6); Richardson and Ampt, 1994 (7); Stopher and Stecher, 1993 (8); Thakuriah et al., 1993 (9)).

Item non-response refers to the failure to obtain complete information from a participating unit. In the context of travel diary surveys, the most significant form

of item non-response is probably the under-reporting of mobility due to respondents' failure to properly recall and/or record all the relevant journeys that they make (see, e.g., Ampt and Richardson, 1994 (10); Brög and Meyburg, 1981 (11); Brög et al., 1982 (12); Hassounah et al., 1993 (13)). Item non-response can be regarded as a particular form of the more general problem of measurement error in survey research (Groves, 1989 (1)).

The objective of the imputation procedures is to obtain a complete data matrix (in this case we talk of "clean data matrix"). This is especially useful when multivariate analysis cannot be achieved on data with missing values. The disadvantage of imputation methods is that they:

- May bias the relationship between variables,
- Complicate the calculation of the quadratic error of the corrected variable
- Without necessarily bias estimates of totals for this variable.

It is therefore necessary not only to adequately describe all the imputation procedures used but also to create dummy variables, called "flag" that would score in the imputed data file. This would leave the option to the statistician to judge the influence or not of the imputed data and change the imputation methodology if necessary, but also to take into account when calculating confidence intervals.

2.7.4 Practice of imputation for national travel surveys in European countries

Not all European countries employ methods to increase the response rate during the course of the survey. Re-contact is not always the only way to increase response rate to have more respondents.

In Germany MiD, 42,48% of the gross sample is not contacted by phone so it becomes postal sample and survey is sending by postal way in MID in 2008. Households do not return postal surveys added to those that refuse CATI system are treated like final non-respondents. And then weighting procedure is applied.

Opposite happens in Belgium, the homes that did not respond were contacted by telephone if it was registered.

In Spain, sample is stratified and households are randomly selected. For each household, three others household are selected with the same socio-demographic characteristics and belonging to the same strata. If the selected one refuses, the others take his place.

Table 2.12: Problems and solutions for non-response in NTS in European Countries

Problems regarding non-response		
Country	**Problems**	**Deal/measures/solutions**
France, NTS	Few partial non-response, refusal	Uncompleted questionnaires rejected, police and services advised, send 2 letters explaining the situation and inviting them to answer, looking for something better than phone directory but it's not easy to find
Israel, NHS		3 methods tested: CAPI-2visits (with or without GPS); 1 visit+ CATI; 1visit + CAWI. Better results with 2 visit
Norwegian, NTS	20% phone numbers; problems with the 20ies and older 70	Advance letter; diary and info; motivation call; interviewers extensive training (seminar of experiences); weighting: geography and age; CATI
Netherlands, NTS	Refusal of 25% and no contact 5-10%	Weighting; adjustment (use info from administrative data) and reduction (call back approach and basic-question approach)
Denmark, TU	24% of respondents are not contactable by phone. Largest single reason is "No contact on number" with 11%.	Improving introductory letter, in order to get more interviews on the web. (Which is not influenced by telephone issues). Over sampling is used from 2012
Finland, NTS	Groups (men 17-40, women over 65), language problems, refused 33%	Stratified random and weighting factor is calculated for each stratum separately, extend the period of reaching the person, up to 30 contact calls; call family members to find the reason why the selected isn't reachable
Spain, NTS	Refused 45%: lack of confidence, lack of time, not found, no located…	Face to face, selection of a reserve list of three households in the same sample area with similar size-age characteristics
Spain, regional TS Catalonia		Non-respondent were substituted by similar individuals according to age, gender and sample area, CATI interview, weighting factors to assure representatives
Spain, local TS Madrid: household+non-residents+drivers and taxi		Face to face, CATI and internet selection of a reserve list of six household in the same area sample with similar size characteristics of the main household list, members can choose the method to complete the survey
Belgium, NTS	Differential response rate per region and per age	Weights assumption, changed from 1999 to 2009: household to person-based survey and postal/telephone to face to face
Czech Republic	No national survey, response rate low	Frequency-based survey after 2000, but no updated info
Germany, mobility panel	2 bias: socio-eco: weighting procedures; not related to socio-eco: problem: very active or very inactive	

3 Towards Comparable Passenger Travel Statistics in Europe - Recommendations for Obtaining Comparable Results from National Travel Surveys

3.1 Introduction

These recommendations have the following objectives:

- Provision for comparable survey results in time and space: Allow acceptable degrees of freedom for specific survey characteristics while still providing for a suitable degree of comparability of survey results
- General best practice recommendation for travel survey design: Give recommendations for travel survey design
- Need for future research: Identify research needs aiming at a higher degree of comparability, specifically on the issue of post-harmonization, i.e. harmonized analysis

Such recommendations depend on the objectives of the data use. The recommendations in this document were developed for the objective of obtaining comparative and post-harmonized statistics specifically with regard to the following travel figures: share of trip makers on among population on a given day, trips per person, passenger distance travelled, time spent travelling, mode share, travel purposes, car ownership, and license holding at nationwide level. Additional figures may be added to this list in the future as the harmonization of travel surveys in Europe proceeds.

Working Group 4 “Household travel surveys” (WG 4) has pursued this goal by producing a set of post-harmonized multinational look-up tables (cross-reference tables) which achieves a far better degree of comparability of survey results than what has already been published. It also is more useful for decision makers, provided they don’t on specific subgroups, such as urban cores or suburbs of large cities, small towns, rural areas. Mobility statistics for such subgroups can currently not be post-harmonized because definitions of such subgroups – specifically with regard to geography, are not harmonized across countries. On this basis we believe that the travel surveys which have been selected for this study and which represent the best practices in their respective countries lead to largely comparable results despite of the differences in their methodologies.

In the following we present important survey characteristics for which various alternative options exist and which WG 4 has examined. From our assessment, some of these options are within an acceptable range as regards comparability of results across surveys, i.e. they allow for comparable survey results (potentially appropriate ex-post-harmonization procedures have to be applied). Others are outside this range and should not be used if comparability of survey results with other surveys is desired. Therefore, we suggest that no comparison should be attempted if such diverging methods are applied.

Moreover, it is often not only a single survey characteristic, which is crucial for comparability. There might also be combinations of acceptable approaches, which lead to survey results, which are not comparable to the mainstream of surveys. In other words: If an approach is chosen which is outside the acceptable range of approaches, the survey is very unlikely to be comparable. However, even if acceptable approaches have been selected for each survey characteristic this does not automatically ensure comparability.

3.2 Survey Characteristic: Method of Collecting Trip Level Information

3.2.1 Introduction

There exist different survey modes for collecting trip level information from the respondent. In the past and still today most large-scale household travel surveys elicit trip information based on conventional methods such as self-administered Paper-and-Pencil Diaries (PAPI), Computer-Assisted Telephone Interviews (CATI), Web-Interviews (CAWI), and Face-to-Face-Interviews (F2 F; CAPI). Increasingly surveys use a mix of these survey methods (mixed mode surveys). Tracking technologies represent a new generation of survey modes. These are GPS, GSM or other devices that enable tracking.

3.2.2 General best-practice recommendation

Countries have a variety of reasons, survey objectives and constraints why they opt for a specific survey mode in order to capture trip information. Therefore it is not appropriate to recommend one specific survey mode. We endorse mixing survey modes, e.g. using a supplementary web-survey or automated tracking of cars in addition to a traditional trip diary, in order to mitigate the shortcomings of individual survey modes.

3.2.3 Consequences for comparability of results

The survey mode impacts on the response bias as well as on data format and quality. Therefore, the survey mode has a clear mode effect on survey results. This is not only true when comparing data from surveys with different conventional methods, but even more so when comparing data from conventional surveys with data from surveys with tracking technology.

3.2.4 Provision for comparable survey results

For practical reasons it is not realistic to prescribe a specific survey mode to provide for result comparability. Results from surveys with the various conventional

survey modes can be made suitably comparable using ex-post-harmonization measures. For the time being, we recommend using a conventional survey mode or combinations of these modes. In addition, e.g. for a sub-sample of the survey, a tracking survey mode might be used. If a survey relies exclusively on a tracking survey mode, comparability with surveys using other survey modes will be very difficult to achieve. If different surveys combine both conventional survey modes and tracking technology, this may ensure a higher degree of comparability than can be achieved exclusively with conventional modes.

3.2.5 Need for future research

Research is needed to develop methodologies that enable ex-post-harmonization of survey data, which has been collected using different survey modes. Currently, the focus of such research should still be on ex-post-harmonization of data from conventional survey modes. Increasingly, the focus of such research should move on to tracking technologies.

3.3 Survey Characteristic: Reporting Period and Repeated Participation

3.3.1 Introduction

The most common travel survey format is the cross-sectional one-day travel survey. In this type of survey respondents participate once and report on their travel behaviour over a one-day period. However, for a number of reasons there is increasing interest in surveys with a) longer reporting periods (multi-day surveys) and b) repeated participation (panel surveys). One reason for both is the expectation to obtain more trip level information from individual respondents resulting in lower cost per trip information as costs for recruitment of respondents are fixed. Moreover, multi-day surveys (a) capture information about behavioural variability of travellers over multiple days, e.g. multimode mode use behaviour. Panel surveys with repeated participation (b) enable the analysis of the development of individual travel behaviour over time, e.g. over several years. Because of the strong day-to-day variability of travel behaviour, panel surveys only make sense if the reporting period during single waves covers multiple days.

3.3.2 General best-practice recommendation

If no substantial objections such as serious concerns about too much respondent burden and resulting sample bias exist, then it can generally be recommended to collect travel information on multiple days can be made. This is because variability of travel behaviour, specifically multimode mode use, is likely to be increasingly important. So far, panel surveys in the field of travel are rather the exception. Their establishment is subject to specific institutional requirements.

3.3.3 Consequences for comparability of results

High-level aggregate statistics, such as mode shares, can generally be produced in a comparable manner with one-day cross-sectional surveys as well as with panel and/or multi-day surveys. There is indication that the higher respondent burden of multiday surveys and the attrition of panel surveys can lead to selectivity, e.g. because low mobility respondents are likely to drop out of the survey as they believe they are not relevant for such a survey, or frequent travellers tend to stop reporting because of excessive burden. Such selectivity problems can seriously impact on comparability of key result and options to mitigate this problem ex-post are limited. In multiday surveys it must be made sure that recall issues are not aggravated because respondents fill in diaries on the last of several reporting days.

3.3.4 Provision for comparable survey results

It is not necessary to recommend a specific survey type in terms of repeated participation or reporting period as survey results are in principle comparable across these survey types. However, selectivity in multiday and / or panel surveys must be scrutinized and corrected ex-post (e.g. by weighting) if necessary.

3.3.5 Need for future research

Research is needed to develop methodologies for controlling survey selectivity and develop appropriate correction procedures.

3.4 Survey Characteristic: Coverage of days of the week and periods of the year

3.4.1 Introduction

Travel surveys generally attempt to capture travel data representative of the entire year and all days of the week. However, in the case of some surveys the decision has been made to concentrate on a) specific periods of the year or b) specific days of the week. The rationale for a) is for surveys with relatively small samples to reduce variation over the year and capture information for a season which is considered representative. The rational for b) is that some days are considered more important than others (e.g. workdays) because this is when more traffic problems occur. However, with an increasing importance of non-work travel this argument loses substance.

3.4.2 General best-practice recommendation

A general best practice recommendation is that surveys should be a) representative for the different seasons of the year (i.e. with sufficient sample sizes

for each period of the year) and b) for all days of the week (incl. working days, Saturdays, and Sundays). However, there will be cases, e.g. due to budget limits, where either a) or b) cannot be achieved. In any case, the survey reporting day(s) should be assigned to the respondent at random, otherwise there is a danger of.a selective choosing of reporting days.

3.4.3 Consequences for comparability of results

If based on a well-grounded selection of the survey period, it is possible that surveys which were conducted only during specific seasons or months of the year represent the year well enough to be comparable with all-year surveys. In these cases, the balance between periods of the year with normal or exceptional travel patterns (e.g. winter and summer holidays) should be object of great care. In any case local characteristics, e.g. climate, have to be considered. Comparable key figures for different periods of the year are not feasible in this case. As most common key figures on travel, such as mode share, refer to all days of the week (and are not restricted to specific days), data collection only during specific days would limit result comparability significantly.

3.4.4 Provision for comparable survey results

Unless comparable travel figures for different periods of the year are explicitly desired, there is no need to prescribe covering the entire year in a survey. Figures for a representative day of the year may be obtained from surveys conducted during specific seasons if precautions are taken. We strongly endorse covering all days of the week in travel surveys, otherwise comparability will be inhibited.

3.4.5 Need for future research

Research should be conducted to make sure, specific seasons are representative for the year (something that might differ between countries). Appropriate ex-post harmonization procedures might need to be developed to address this.

3.5 Survey Characteristic: Continuous Survey Conduction and Repetition Frequency

3.5.1 Introduction

Most travel surveys are conducted as one-off surveys or as part of survey series with several years in between the single surveys. Since the 1990s, however, an increasing number of (national) travel surveys are conducted as a) continuous surveys (running permanently day after day) or b) annual surveys (surveying travel annually during certain periods of the year). First, see some institutional

and cost advantages in continuous and annual surveys as these can rely on experienced staff and an established procedure. Attributing changes of survey results to even slight changes in methodology is easier in this case. Second, continuous and annual surveys enable observing how travel evolves over time, either in reaction to short term events (e.g. soaring fuel prices, economic crises) or determined by long-term trends (e.g. ageing population, sub-urbanization) Third, continuous / annual surveys enable pooling of data from several years to increase sample sizes for specific analyses. Typically, for a given year, continuous or annual surveys have smaller sample sizes than cross-sectional surveys. Continuous or annual surveys can also be combined with supplementary cross-sectional large sample surveys conducted at larger intervals (e.g. in Germany).

3.5.2 General best-practice recommendation

The general best-practice recommendation here is a continuous survey, annual surveys are second best. This, however, requires a certain institutional framework and commitment of the sponsors, data users and analysts. As less frequent survey conduction does not seriously impact on result comparability, other designs are acceptable, too.

3.5.3 Consequences for comparability of results

In principle, results from continuous and annual surveys are comparable to results from surveys with other designs. However, for good comparability it is preferable when the years which survey results refer to match. For instance, comparability of time series from different countries can be limited if reference years of results differ too much. This problem is aggravated when some survey years fall in an economic recession while others have been conducted in times of growth. Continuous and annual surveys avoid this problem and offer most flexibility here.

3.5.4 Provision for comparable survey results

There is not yet a good possibility to interpolate travel demand figures for years in which no survey has been conducted, e.g. for years in between irregular surveys. For this reason, there is no possibility to enhance result comparability if survey years do not align. Recommending annual or continuous surveys is the only option to ensure best survey comparability for the same reference years.

3.5.5 Need for future research

Explore the institutional, administrational, financial advantages of continuous and annual surveys to convince survey sponsors, both public and private, to support such survey designs.

3.6 Survey Characteristic: Types of Travel Covered

3.6.1 Introduction

In principle, travel surveys aim to capture all types of travel. However, for practical reasons some segments of travel might be deliberately excluded or not captured in detail by a survey. One typical example is the exclusion of travel activities abroad if a survey only aims to cover travel within the respective country. Another typical example is that series of trips - specifically if conducted in the context of the respondents' job (e.g. taxi drivers, delivery services) - may not be covered in detail or even excluded (e.g. details of delivery tours). The most important reason is the high respondent burden when having to report such trips (evidently this concern does not exist in the case of surveys using tracking technologies). Some surveys capture information on such travel activities with a lower degree of detail, e.g. by simply collecting the number of trips and total distance travelled during such travel activities.

3.6.2 General best-practice recommendation

We recommend capturing travel as comprehensively as possible. This, however, has to be traded off against the respondent burden. Capturing specific segments of travel such as series of trips with a lower degree of detail is acceptable. In any case, we recommend keeping as much travel information, which has been elicited, from respondents as possible (e.g. about travel abroad, especially in border regions) in the micro data set.

3.6.3 Consequences for comparability of results

The consequences of not capturing some exceptional segments of travel in detail are unlikely to be severe. This is because most of the relevant comparative statistics are probably only affected marginally, even though some professional travels, sportive walking or cycling can last excessively long or travels abroad cover very long distances. However, each survey that does not cover specific types of travel reduces the overlap of travel, which is covered by all surveys.

3.6.4 Provision for comparable survey results

Inconsistencies between surveys as regards the types of travel that they cover can be harmonized ex-post (if they are identified as being relevant at all). This is possible if analyses across surveys concentrate on the overlap of travel activities covered by all surveys. This, however, requires that each survey defines which types of travel are not covered (e.g. mobility of people living in institutions).

3.6.5 Need for future research

Research should be dedicated to develop approaches to capture some core information about travel, which is not covered in detail yet; this core information may also be useful to impute trips, which have not been covered in the survey in detail.

3.7 Survey Characteristic: Capturing important categorical travel information (mode and purpose)

3.7.1 Introduction

Important categorical information about single travel activities are a) mode and b) purpose of travel. Often, the mode of travel (a) is elicited as the main mode across the stages for entire trips. However, there is increasing attention on trips combining several modes, vehicles or drivers (e.g. carpooling). In many surveys, respondents report the usage of multiple modes per trip and make the difference between car as driver or passenger. Stage based surveys, which capture information for each stage of a trip, deliver the highest degree of detail here. The purpose of a trip (b) is the activity at the end of the trip. In the case of escorting, the passenger's purpose should be elicited because it determines the destination. In some cases, the purpose/activity itself can involve travel/physical movement (e.g. walks) and the trip can either be a loop or cut in two halves. Both, mode and purpose are usually captured in surveys through pre-defined categories, sometimes with the possibility to supply additional information. In surveys using tracking technologies travel modes can be algorithmically identified based on the tracked data (e.g. acceleration, speed, vibration); purposes based on the characteristics of the destination.

3.7.2 General best-practice recommendation

We recommend eliciting mode use information for different stages of trips. However, stage based surveys involve higher respondent burden than trip based surveys; therefore stakeholders might opt against them. A list of successive means used during a trip, complemented with walking and waiting times is an alternative to stage descriptions. In any case we suggest providing for a sufficient number of mode / purpose categories in order to facilitate different combinations which enable comparability. We also strongly recommend explicitly identifying return home trips as a specific purpose in order to be able to identify journeys unambiguously.

3.7.3 Consequences for comparability of results

For both mode and purpose it is important that the elicited categories are comparable across surveys or can be aggregated into matching categories. This is best ensured if comprehensive and sufficient categories are provided. As regards mode, the focus for comparative statistics is on the main mode of trips (intermodal

mode combinations are secondary). While modes of travel are usually unambiguous, trip purposes can be ambiguous and might be interpreted differently in different cultural contexts. Comparability of trip purpose information is therefore more difficult than mode information. Moreover, data elicited with tracking techniques might not be comparable with that from other surveys.

3.7.4 Provision for comparable survey results

For both mode and purpose, categories must be comprehensive, sufficient and provide for the possibility to combine responses into categories, which represent common denominators across surveys. If this is the case ex-post-harmonization is usually possible. Attention has to be given to cultural biases when identifying trip purposes and identifying purposes and modes in data collected with tracking techniques.

3.7.5 Need for future research

Research should be dedicated to the development of algorithms to identify mode and purpose from tracked data in such a way that they are comparable to other surveys. Moreover, the heterogeneity of reported purposes caused by cultural biases should be investigated.

3.8 Survey Characteristic: Collecting trip origins, destinations and trip distances

3.8.1 Introduction

Travel distances represent one of the most important figures to describe travel demand. Therefore, trip distances are essential information at the trip level. In conventional surveys, trip distances can be either captured through self-estimated trip distances or based on trip origin and destination geolocalisation, e.g. through collecting address information. The collection of trip geolocalisations has other advantages, e.g. measurement of traveller flows, and enables specific types of modelling, e.g. mode choice modelling for which attributes of alternative modes for specific routes need to be available. Nevertheless, there are stakeholders who opt against trip geocoding, mainly because of data privacy reasons or to reduce respondent burden in the case of trip diary surveys.

3.8.2 General best-practice recommendation

The different approaches for collecting trip distances and trip geolocalisations have their disadvantages, e.g. questionable reliability of self-reported distances and completeness of tracked routes. Therefore, we endorse combining these modes to overcome these problems. However, countries have a variety of reasons, survey

objectives and constraints why they opt for capturing trip distance in a specific way and it is therefore not appropriate to prescribe one specific option.

3.8.3 Consequences for comparability of results

The way that trip distances are assessed, impacts on travel distance results from surveys. One reason for this is that respondents often misestimate the distance travelled when reporting self-estimated travel distances. Another reason is that algorithms to compute travel distance (route distance) potentially assume wrong routes. However, empirical work has shown that these biases are tolerable in total. Crow-fly distances from origin to destination, when geocoded at the address level, are probably less subject to erroneous estimates.

3.8.4 Provision for comparable survey results

For practical reasons it is not realistic to recommend one specific way how trip distances should be collected. Results from surveys with different approaches to capture travel distances can be made suitably comparable using ex-post-harmonization measures. Therefore we recommend allowing for different approaches to collect travel distances. However, suitable ex-post-harmonization measures must be developed to make survey results comparable.

3.8.5 Need for future research

Research is needed to develop methodologies that enable ex-post-harmonization of trip distance information, which has been collected using different approaches.

3.9 Survey Characteristic: Treatment of geo-information about residential environment and trip ends and enriching of data sets

3.9.1 Introduction

All travel surveys collect and make use of geographical information at some stage of conducting the survey, e.g. address for contacting the households at their place of residence. Many surveys even collect geolocalisation on the trip level (see above). From a certain level of precision (depending on the number of persons that share a same geographical reference, e.g. address, zip code, administrative or statistical areas) a geocode is a confidential data.item. Privacy protection laws impose to limit its availability for third parties. In many countries, addresses are not entered into the survey database or deleted from it at a later stage. However, precise geolocalisation is necessary to add geo-information to the data set, such as population of the municipality, categories of the residential neighbourhood, population densities,

weather, network conditions, attributes of alternative modes of travel etc. This information can later be used by the data analyst to analyse travel behaviour in the spatial context, even if precise individual address information is not available. An option to make use of this information without conflicting with data privacy regulation is to enrich the data set while the survey is still going on. Comparability problems arise a) over time because new geographical categories appear which cannot be applied to older data, b) across countries in Europe, because such categorical geo-information is not harmonized across countries, starting with the definition of municipalities. As a result, meaningful comparisons of travel behaviour across Europe for different spatial categories (e.g. rural vs. urban) are currently not feasible because of the lack of relevant standard definitions (e.g. about population or job density).

3.9.2 General best-practice recommendation

As a general best practice recommendation we suggest to elicit geolocalisation at the finest level (addresses, zipcodes, enumeration districts) and save this information for each relevant unit of the data set (households, trips) in the format of geographical coordinates. To address data privacy concerns we suggest separating this information from the public/scientific use database for use and specifying the terms and conditions for accessing this private data. This way the geo-codes will stay available for use as better and more harmonized categorical geo-information at the European level becomes available in the future. In addition, the survey process should include the necessary enrichment for the later analysis.

3.9.3 Consequences for comparability of results

If no action is taken on this problem, also in the future there will be no possibility to compare travel behaviour for different spatial categories across Europe.

3.9.4 Provision for comparable survey results

As said above, we endorse eliciting and saving geo-codes / addresses. If this is not possible, geo-locations should be saved at the finest possible resolution, seeking compatibility with for European LAEA 1 km grid (EEA, 2013), especially in countries that produce, or intend to produce, statistics in that grid.

3.9.5 Need for future research

Intensive research should be dedicated as soon as possible to develop a set of relevant indicators (densities, transport supply, accessibility etc.) and to harmonize categorical geo-information for these indicators across Europe. Research should also be directed to the possibilities to save and make use of geo-codes/ address information in accordance with the data privacy regulations of the European countries. Moreover, it should be investigated which variables are recommended when enriching a data set and how such enrichment may take place.

3.10 Survey Characteristic: Assessing energy consumptions and CO2 emissions

3.10.1 Introduction

Environmental issues are now rising to be one of the major questions that travel surveys have to address by assessing greenhouse gas and pollutant emissions. Since these emissions are strongly correlated to fuel consumption, such analyses give also insights on household travel budgets and their sensitivities to fuel oil prices, which is a traditional concern of travel surveys. Characteristics of vehicles used for travel (e.g. age, engine power, fuel) are key information to elicit. This can be done either by surveying the respondents' vehicles in order to link them with the surveyed trips, or by merging the trip database to a vehicle database with imputation procedures based on the place of residence, age, and gender of the car owner, and, if possible some elements about the household cars.

Collecting of license numbers of the cars for statistical analysis using car register and data on roadworthiness tests could be, if privacy protection allows it, an economic and efficient way to proceed.

3.10.2 General best-practice recommendation

Merge travel survey data as much as possible to vehicle registers based on license numbers, technical control registers (road worthiness tests), provided such registers exist and are reliable. Second best: survey vehicles despite of the additional burden to the respondent.

3.10.3 Consequences for comparability of results

Imputation of vehicle characteristics should be as controlled as possible because there is empirical evidence that the more polluting cars are either old cars owned by poor and/or rural households, or very powerful and expensive vehicles, especially when used on short urban trips when engines are cold. Imputing average national emission factors or using the exact characteristics of the vehicle that travelled will presumably change the assessments of emissions. It will also bias the assessment of fuel consumption and households' fuel budgets.

3.10.4 Need for future research

Research should be dedicated to developing approaches to combine technical information from the car registers to travel data in the NTS (distance, travel time, time of the day and geolocalisation) in order to estimate energy consumptions and CO2 emissions.

4 Post-harmonisation of data from National Travel Surveys across Europe

The SHANTI group decided to make some look-up tables covering data from the European National Travel Surveys (NTS) to show that it is possible at least to a certain extent to post-harmonise the NTS data. Furthermore, many participants were curious to see how different the travel behaviour is across Europe.

4.1 Post harmonising methods

It was decided to make the tables as simple as possible to be able to get the most correctly harmonised data as possible and to reduce the calculation burden of the participants.

Several questions were discussed before the first step was taken:

- Which period should be covered, development over the years or only the latest years?
- How can we make sure that the coverage of the data is similar across countries according to for instance age groups, weekdays, time of the year etc.?
- Should we ask for one big table with many variable crossings so that it is possible afterwards to extract the travel behaviour variables in the combination that the user might prefer? Or should we decide for a few predefined crossings of what was found to be the most important?
- Which travel behaviour characteristics are most important and therefore asked for and which grouping of the respondents?
- Which travel behaviour indicators should be asked for?

Another important question was which countries it would be possible to cover. This depends first of all, on which countries had conducted a NTS during the period decided to cover. Furthermore it depends on which data the SHANTI group has or could get access to.

Below the 6 questions are discussed and the decided conclusion is reported.

4.1.1 Which period and which countries should be covered?

At first the SHANTI group had hoped to be able to cover the development since 2000 and therefore asked for a first set of tables for both 2001-2005 and for 2006-2010. However, the first period was given up. First because it showed up that considerably fewer countries had data for the first period than the latest. Second because the work with setting up the data set for calculation of the tables was the most burdening part of the job with making the look-up tables. Only one data set was provided for 2001-2005 at the first deadline for data collection.

15 European countries have conducted a national travel survey, but only data from 11 countries is included in this report.

Two countries are unfortunately not willing to provide members of the SHANTI group with data. In Italy a NTS has been conducted for several times in the last years. However, for some reasons the data cannot be provided for any research institutions and the results of the survey are kept secret! In Latvia surveys have been conducted in 2003 and 2008 but the Ministry of Transport is not willing to provide the SHANTI member research institute with data to be able to construct look-up tables. A NTS has been conducted for Cyprus during the period, however nobody from Cyprus are member of the SHANTI group so tables from Cyprus are not included. 2 countries did not carry out a survey in 2006-2010, Finland and Austria. Finland finished their latest survey in 2011 so it was accepted to include data from Finland. The latest survey from Austria is from the 1995 and the next is planned for 2013.

For Spain a big number of tables have been published and are available for the SHANTI member university. The original micro-data was unfortunately not available so it has not been possible to make the post-harmonisation as far for Spain as it would have been with micro-data.

Germany has two surveys, the MiD and the MOP which have both provided tables. Furthermore a survey from the Barcelona region is included in the look-up tables. The tables are therefore based on 13 surveys. This table gives an overview of the available surveys:

Table 4.1: Countries with a survey, which is included in the post-harmonisation

Country/Region	Survey	Status
Barcelona	2006	OK
Belgium	2010	OK
Switzerland	2010	OK
Germany, MiD	2008	OK
Germany, MOP	2006-10	OK
Denmark	2006-10	OK
Spain	2006	Only available as tables
Finland	2010-11	OK
France	2007-08	OK
Netherlands	2006-09	OK
Norway	2009	OK
Sweden	2005-06	OK
Great Britain	2006-10	OK
Cyprus	2009	Not member of Shanti
Italy	?	Data are secret
Latvia	2007	Data cannot be delivered
Austria	1995 / 2013	Not actual

Three countries (Denmark, Netherlands, and Great Britain) and the German MOP are running a continuous survey. These countries deliver tables based on aggregate data for the whole period. Due to a changed methodology in 2010 data from the Netherlands only include 2006-2009 for the aggregation. For the rest of the countries a survey covering one year is conducted.

4.1.2 Post-harmonising surveys

The purpose of post-harmonising NTS to compare travel behaviour between the countries is to reduce conditions, which make the reported behaviour different. Such conditions could be:

- The covered population groups
- Data collection methodologies
- The covered period of the year and the week

4.1.2.1 The included population groups

Differences in travel behaviour according to the post-harmonised look-up tables might stem from the fact that data are collected for different groups of respondents. The most important known difference is differences in age groups. If a country is not including for instance the oldest age group the resulting travel pattern according to the look-up tables might result in more and longer travels per respondent, a higher share of commuting trips, and a higher share of travels by car as driver than for other countries due to the missing travels from elderly people.

In the post-harmonising process it is decided to reduce the look-up tables to include only the age groups, which all countries include in their sampling process. Norway has the highest start age, 13 year, and Denmark and Sweden as the only countries have an upper age limit, which is for both 84 year. This results in an age limit for all look-up tables to 13-84 year.

The four Nordic countries and the Netherlands sample individual respondents independent on which kind of household they live in, except that Norway is not including respondents in institutions and other multifamily households. The rest of the countries sample families or households for which either some of the household members or all the members are or ought to be interviewed. The look-up tables are based on the individuals who are interviewed. This is resulting in differences in the included respondents, which are no more representative for the population according to age, gender and household size. The countries might have taken care of this in a weighting process.

Other differences might exist in the sampling or in the contact process for interviews, but they are less known and therefore impossible to take care of. Known differences stem from which extend non-national respondents are included in the sampling and how language problems are handled.

4.1.2.2 Data collection methodology

Data collection methodologies are impossible to post-harmonise, they are the fundament the results are based on. However, it is important to be aware of effects on the reported behaviour, which could stem from differences in the data collection methods.

One effect is differences in response rates, which can stem from both the way to contact the respondents (by phone, by personal contact, or by letter with request to answer by web or by paper and pencil) and the number of attempts to contact the potential respondents.

The differences in response rates might result in biased samples of the population with for instance less travel activity because the travel active sampled respondents are more difficult to get contact to, or less low income and social marginalized groups because they don't have access to web or telephone, or because they are little at home or even don't have a home.

A few countries are using a combination of methods to contact the respondents, which reduces the biases stemming from the methodology. The Netherlands has for instance since 2010 combined web, telephone calls, and face-to-face and Denmark has combined web and telephone calls in the whole period since 2006.

Some of the differences in response rates are taken care of in an up-weighting based among other things on age group, gender, and geography. However, differences in behaviour, which are dictated by conditions not taken into account in the weighting procedure, are impossible to correct by the weighting procedure. And the weighting procedures are different between the countries too.

Differences in the contact methodology are also influencing the carefulness and frankness with which the respondents are answering. Telephone interviews are for instance resulting in less carefulness in the answers because of a feeling of time pressure, which is less the case when filling in a survey on the web. This is resulting in remembrance of fewer trips. On the other hand web interviews and paper and pencil makes it less possible to give the respondents explanations/instructions which is resulting in more mistakes and a need for post processing with web interviews.

Furthermore, language problems or less ability to understand the questions and to fill in complicated questions might result in lower response rates or in item none response which is most problematic if travels are left out from answering resulting in less travel activity. A special effect might stem from a kind of soft refusal when respondents claim they have no trips or fewer trips than is the case to stop an interview, which they in fact do not want to participate in. Problems of this kind are more difficult to distinguish between surveys when assessing differences in post-harmonised surveys.

4.1.2.3 Data collection period

For the post-harmonising process two kinds of problems with time period have to be considered, problems related to the period the data are collected in and for and problems related to the time span the survey is covering.

Most NTS's are asking for a one-day diary, some from the day before the day contact is obtained, and some from a predefined day. Two countries (France and the Barcelona region) are asking for both the day before the interview and for a day in the preceding weekend. This is presumably done to cover both workdays and weekends with less respondents and therefore with lower expenses. Problems with remembrance because the surveyed travel day is too far back in time might however result in too few travels, especially fewer short travels. In the Finish and several other NTS the travel day for which the diary is conducted is kept fixed if contact is not obtained at the planned day and the interview is taken up one or more days later. This might result in even bigger problems with remembrance. The same is the case for interviews covering longer periods than one day, which is the case for the British NTS and the German MOP. The respondents therefore get a jogger to fill in advance to support the memory. In Great Britain only the diary for the last day covers the shortest travels and only this day is used for assessing the overall travel pattern – and also the only that is used for post-harmonisation.

Another problem is the fact that travel activities are very different between days in the week, especially between weekends and workdays, according to all the important behavioural indicators as travel purpose, transport mode, and destination and by this the travel distance. Post-harmonisation is therefore impossible between NTS, which only cover the whole week, and surveys that only cover for instance workdays. Luckily all European NTS cover both workdays and weekends, which makes comparisons possible. An uneven coherence of the five workdays or the two weekend days might also influence the reported travel behaviour. Such difference should be taken care of by a weighting procedure for each country in which all weekdays are weighted evenly. If this is the case we have not controlled.

Travel activities are also changing over the year. Surveys conducted during a full year will therefore be the most representative. If only a shorter period is covered some differences might exist according to this. Countries, which are only covering a short period, might choose a typical period in the spring or autumn without bank holidays or other school holidays. This means that the travel activity is more workday-like in these countries than NTS in other countries that includes both bank holidays and the longer summer and winter holidays. However, all countries cover a full year.

The difference due to leaving out holidays might be smaller than expected because all NTS that makes diaries for one or a few days are covering holiday periods rather rudimentary.

4.1.3 The collected tables

4.1.3.1 Complexity of tables

The SHANTI group had a long discussion whether we should ask for one big table for which many variables are crossed Or if we should decide for a few predefined crossings of what was found to be the most important.

The spokesmen for the first solution with a big table pointed out that it would be possible afterwards to extract the travel behaviour variables in the combination that the user might prefer. In this way it was possible to have much more flexible information. The spokesmen for the last solution wanted to make it as simple as possible.

It was finally decided to ask for 3 tables with 2-3 variable crossings. When these were made we asked for 2 more tables with 2-3 variable crossings.

When the data were collected it showed up to be a good decision to ask for simple tables because it was rather difficult to explain the needs to all. Furthermore weighting is complex for some of the countries especially France which makes it complicated to construct tables in many levels and to extract simple tables from more complex tables. See Appendix E: Figures of post-harmonisation of data from National Travel Surveys across Europe for all figures' detail.

4.1.3.2 Travel characteristic included

First of all the post-harmonised tables should give an overview of travel behaviour. The distribution of trips on modes seems to be the most important characteristic of travels and the emission due to travelling. Transport mode is therefore included in all tables. Furthermore, travel purpose gives a good explanation of why people are travelling. The distribution of trips on modes for different purposes is of importance for understanding the mode share and to assess the possibilities to change behaviour. Because of the big differences between workdays and weekends in travel purposes it is decided to ask for a table with a crossing of purposes of the activities and transport modes at workdays and in weekends.

For the purpose of understanding differences between the countries the distribution of trips on travel distances is relevant. Furthermore, travel distances can to some extent explain the choice of transport mode.

Distribution on time use bands is related to the choice of travel modes. At this background two tables with crossings of transport modes was decided, one with travel distance bands and one with time use bands.

Unfortunately the Spanish NTS is not including kilometres. They only ask for time use. By using the time use bands and mean travel distances for the other European countries it has been possible to calculate an approximate travel distance by mode for Spain.

The distribution of travels on distance bands is furthermore important to assess differences between the countries because the definition of a travel is different between the countries. Some NTS only include travels to the border whereas others include travels to a final destination abroad too. It is often mentioned that the diary of daily travels only includes travels up to a certain distance, typical 100 km (for France 80 km). However, all the NTS collect all travels made at the travel day. This makes post -harmonising easier. On the other hand, differences in travels abroad are resulting in important differences in the distribution of distances and for the overall kilometres. The size of the country is furthermore of importance for the share

of long travels. Last but not least the long distance travels are the most uncertain travels because they are rather few and long distance travels often takes more than one day so that the outbound trip is not included in surveys covering only one day.

Another difference between the countries is the definition of the short travels. Some countries include all trips at public networks. Others only include trips longer than for instance 300 meter or 5 minutes. In practice the shortest trips are more often forgotten especially if they are only a stage in combination with public transport. Differences in definitions of short distance travels are of little importance of the overall kilometres but they influence the distribution on modes, especially the share of walking trips.

4.1.3.3 Tables for different groups of respondents

The above-mentioned tables are collected for the population as a whole, which in the post-harmonising sense means respondents between 13 and 84 years. However, it is also relevant to analyse if differences between the countries are due to differences in the most important groupings of the population. Analyses of travel activities show that travel behaviour is dependent between others on age, gender, income, car-ownership, family structure, urban structure, and employment.

Car-ownership is the most important factor of all. Because the decision about car-ownership and the mode share following from this is dependent of the family type it is decided to ask for a table with a crossing of car-ownership, family type and transport mode. Not all countries have the requested family types available so they only provide a table with car-ownership and mode choice.

Age is one of the most important explaining factors. It is a certain extend to covariate with employment. Because the last is more difficult to post-harmonise thanks to different definitions, it is chosen to ask for a table with a crossing between age groups and transport modes. This table also includes the age group from 85 year and up and the age groups less than 13 year. Some countries define this group as 10-12 year, others as 6-12 year or even 0-12 year.

Gender is of less importance than the rest of the factors and income has a high share of item non-response so tables with these variables are not collected.

Finally, many participants in the SHANTI group wanted to analyse the influence of urban structure. However, definition of urban structure is rather different so it was given up to ask for this.

4.1.3.4 Travel behaviour indicators to be included

The most important indicator for travel behaviour is kilometre per traveller or respondent. It is an indicator of the overall travel kilometres and - if the mode is known to some extent an indicator of emissions. It was furthermore decided to collect time use per traveller or respondent to be able to compare some travel behaviour with Spain. Time-use is furthermore showing some of the effects of differences in mode choice.

It showed up that the travel indicators were not so complicated to calculate for most of the participants who program in SAS or SPSS. It was therefore also accepted to ask for trips per respondent or traveller and for the mean kilometres and time use per trip. This makes it possible to calculate the mean speed too.

An important question is if the travel indicators should be calculated per respondent or per traveller. The difference is whether respondents without trips should be included in the divider. It is known from research made by several of the participants that the rate of respondents without a trip is extremely sensitive to the data collection methodology, the way to contact the respondents, interviewer effect etc. It was expected that the kilometre per traveller would give a more correct picture of the travel behaviour than kilometres per respondent. It was therefore decided to collect kilometres, time use, and number of trips per traveller and not by respondent. With knowledge of the share of immobile respondents it is possible to calculate the kilometres per respondent too and compare the two indicators.

4.1.3.5 The requested tables

The finally decided tables are shown in Table 4.2. Each table includes transport mode and one or two other variables.

Table 4.2: Structure of the 5 chosen tables

Main entrance	Eventual second entrance	Entrance for all tables: Transport mode	
Distance band		Km per traveller	Number of travellers
Time use band		Time use per traveller	Number of trips
Working day / Weekend day	Purpose	Number of trips per traveller	Up-weighted number
Age group		Mean distance	Of travellers
Car-owner ship	Family type	Mean travel time	

Furthermore, is asked for a table showing the number of respondents who are travelling the actual day and those who are not. The figures are collected for both the number of respondents and the weighted number.

4.1.3.6 Values of the variables

The values of the chosen variables are shown in Table 4.3. In practise it showed up that several countries had a variable value ‘Don’t know’ which therefore has to be added.

A comment should be added to the definition of some of the variables:

Main mode is for most of the countries defined as the mode used at the longest distance if a trip includes more than one stage. A few countries use a hierarchy so that the mode highest in the hierarchy is the main mode.

Purpose can be defined in several ways because a trip has a purpose in each end. If the purpose in one end is 'home' the purpose in the other end is chosen so that home is not a purpose. If a trip has two none-home purposes the purpose at the destination is chosen as purpose. This way of defining purpose is not the optimal because it results in an overrepresentation of the last purpose before home. Alternative ways of defining the purpose for trips with more than one purpose are to choose the activity where the respondent stays for the longest period or to choose the purpose farthest away from home. Definitions of this kind are however more complicated to implement, so again the simplest definition is chosen.

Except for Spain all countries are able to make tables with the shown values and indicators. German MOP, Finland, the Netherlands and Barcelona are not able to deliver the requested family groups. Barcelona is furthermore not able to distinguish between one and more cars in the household. Spain is not able to deliver a table with car-ownership.

Table 4.3: Post-harmonised values for the included variables

Main mode	**Trip distance bands**	**Travel time use bands**
Walking	0 to under 2 km	1 to under 5 min
Bicycle	2 to under 5 km	5 to under 10 min
Moped and Motor cycle	5 km to under 20 km	10 to under 25 min
Car driver	20 km to under 50 km	25 to under 50 min
Car passenger (including taxi)	50 km to under 100 km	50 to under 90 min
Public transport	100 km and up	90 min and up
Others (plane, tourist-bus, ferry)		
Purpose	**Car ownership**	**Age groups**
Commute/Education/ Work related/Business	No car in family	< 13 year
Shopping and Errands	One car in family	13-19 year
Leisure	Two or more cars in family	20-29 year
Escorting		30-39 year
		40-49 year
Workdays / Weekend Days	**Family size**	**50-59 year**
Monday, Tuesday, Wednesday, Thursday, Friday	Single	60-69 year
Saturday, Sunday, public holidays, Christmas etc. (if possible)	Single with children less than 18 year	70-79 year
	Couples without children	80-84 year
	Couples with children and other families	85 and up

4.2 Comparison of the post- harmonised tables between the countries

4.2.1 An overview of the surveys

The 13 surveys the look-up tables are based on are of very different size (Table 4.4). The biggest is the Dutch survey with 177,000 respondents covering 4 years followed by the British and Danish surveys with 80-75,000 interviews both covering 5 years. The German MOP survey is covering 5 years too but it only has 8,000 respondents. However, each respondent are asked for all travels during a week leading to 194,000 included trips which is at level with several other survey.

Table 4.4: Key variables of the 13 surveys the look-up tables are based on

Country	Survey	Trips	Respon-dents	Travellers	Immobile	Immobile share
Barcelona	Barcelona 06	162,106	41,658	32,041	3,163	9%
Belgium	BE 2010	34,301	14,083	10,145	3,938	28%
Switzerland	CH 2010	197,020	57,038	50,455	6,583	12%
Germany, MiD08	DE Mid08	164,493	53,587	48,016	5,571	10%
Germany, MOP	DE MOP 06-10	193,669	8,006	7,327	4,751	8%
Denmark	DK 06-10	224,525	75,020	62,640	12,380	17%
Spain	ES 2006	204,257	55,352	49,027	6,325	11%
Finland	Fi 10-11	32,600	11,320	9,331	1,989	18%
France	Fr 07-08	97,029	17,163	14,093	3,070	18%
Great Britain	GB 06-10	202,315	79,789	62,131	17,658	22%
Netherlands	NL 06-09	441,963	177,319	146,433	30,886	17%
Norway	NO 2009	94,823	26,105	22,739	3,366	13%
Sweden	SE 05-06	69,105	25,002	20,710	4,292	17%

Except for the MOP the two smallest surveys are Finland's with 11,320 and Belgium's with 14,083 respondents. With only less than 35,000 trips the results from these surveys are more uncertain than the results from the rest.

4.2.2 Share of immobile

Table 4.4 is also showing the number of travellers, which is used for calculating kilometres, time use, and number of trips per traveller per day in the look-up

tables. It furthermore shows the share of the respondents who are immobile at the actual travel day. The share is varying between 8% for the German MOP and 28% for Belgium. For 5 countries the share of immobile is 17-18% of the respondents. The British share is with 22% very high too. In the other end Spain, and the other German survey MiD is with 9-11% in the low end too. Switzerland and Norway are following with 12-13%. These immobile shares are calculated on the un-weighted number of respondents and travellers. Figure 4.1 is showing the shares of immobile based on both un-weighted and weighted data and furthermore for weekdays and weekends. A few of the countries (the Netherlands and Spain) have not been able to get weights for their data.

From Figure 4.1 you can observe that nearly all countries have a little higher immobile share for the un-weighted data than for the weighted data. It is clearer for weekends than for weekdays. The result shows how important weighting is for correcting the data for differences in response rates for respondents with and without any trips. In general respondents without trips are over represented in the surveys. Only for the MOP the opposite is the case for both days, the immobile are under-represented in the MOP. When taking the weighting into consideration the immobile share of the 5 countries with a immobile share of 17-18% is reduced to 16-17%. For the countries with a lower level the immobile share is not reduced.

Figure 4.1: The number of immobile as share of the respondents calculated on the un-weighted figures (respondents) and the weighted figures

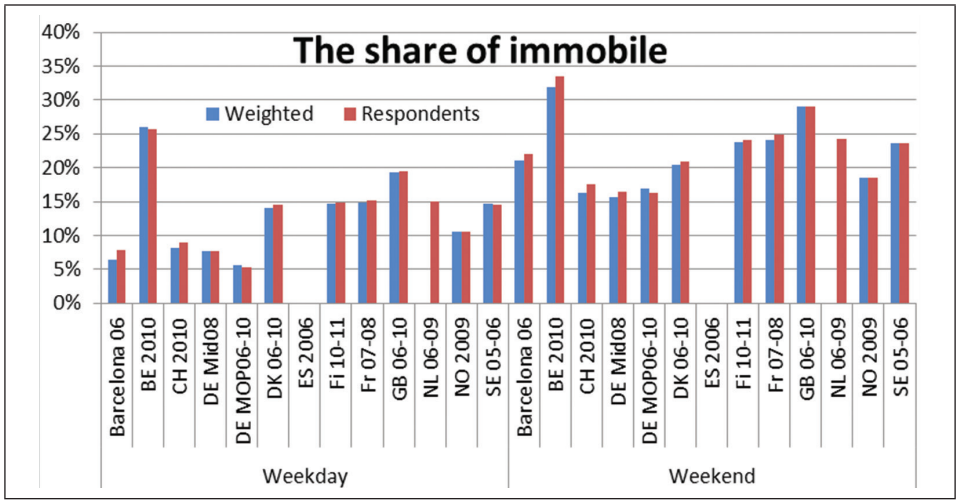


Figure 4.1 is furthermore showing that the share of immobile is higher in weekends than weekdays. We again observe two groups of surveys, one with around 8% immobile at weekdays and 16-17% in weekends, and another with 15% immobile at weekdays and 21-24% in the weekend. Barcelona, belonging to the group of countries with a low share of immobile in weekdays, and France belonging to the middle group at weekdays are having a relatively higher share of immobile in the weekend than the rest of the countries in the same group. Both countries

ask the respondents for a travel diary for both weekdays and weekends (for Barcelona respondents are only answering for the weekend if they are surveyed at a Monday). People could have a lower remembrance of the weekend travels if they are asked several days back in time. However, Madre, Axhausen, and Brög (2007) show that a delay of data collection is not an explanation for a high share of immobile.

Great Britain has a very high share of immobile compared to the rest. In the British NTS is asked for travels for seven days of which the delivered tables are for day 7. Dickinson and Melbourne (2013) have analysed the level of immobile. They compare the level in the NTS with a survey for the Greater London area carried out by London Transport. This survey is a one-day survey similar to most of the European surveys. This survey shows an immobile share at 14% at weekdays and 22% in weekends for the survey in 2005-06, which is at the level of five of the European countries. Furthermore, they show that the level of immobile is increasing during the 7 days. If the immobile level is based on day 1 instead of day 7 the share of immobile would be 17% which is in line with both the London survey and several European surveys. This indicates some fatigue of the respondents during the reporting period.

This kind of fatigue might also be the case with the weekend interviews for France and Barcelona. At the other hand this is not observed within the German MOP. But you should be aware that this survey is a panel survey, which the respondents have accepted to participate in. Furthermore, the survey is a panel focusing on car ownership, which might push respondents with no car, and only travelling a little away from the survey. This might explain both the unusually low share of immobile and the fact that the respondents without a trip are underrepresented in the survey opposite to the rest of the surveys. It could be interesting to analyse if the share of immobile is higher in the first year than in the second and the third year which might be a further indication of a too low level of the share of immobile.

The low level of the share of immobile in the German MiD could be explained by a two-stage contact to the respondents. First the respondents are asked if they want to participate and background information is collected. If they accept to participate they are later contacted for collecting the diary. It is well known from other surveys that many respondents without trips find themselves irrelevant for a survey about travelling which might result in an overrepresentation of immobile not going on from step one to step two. A very high level of the none-response rate for the German MiD also indicates a risk for a bias in the final population for the diary.

Finally the very high share of immobile in Belgium, 25% at weekdays and 38% in weekends is indicating that the quality of the data collection is too low. Researchers at the University of Namur have compared the results for the Flanders part of the Belgium survey with a survey for Flanders. This shows a difference in the share of immobile but the travel behaviour in the two surveys seems similar.

The conclusion of these analyses and discussions is that the surveys with a very high immobile level and a very low immobile level might be outliers, which are influenced by the quality or the methodology of the data collection.

The next question is if the difference between at the one hand Barcelona, Spain, Switzerland, Norway, and eventually Germany with a low immobile share and at the other hand Denmark, Sweden, Finland, Netherlands, France, and Great Britain with a little higher immobile share is due to differences between the real shares or due to a difference in data collection methodology. Madre, Axhausen, Brög (2007) show that people in dense cities are more out for a trip than people living at the countryside with few shops and other attractions. This might explain the rather low level of the immobile share for Spain and especially Barcelona, which has a high share of population living in dense cities. However, the Netherlands and Great Britain are in the group with a high immobile rate and both countries are densely populated when density is calculated as the population divided by the area of the country. Norway with a lower share of immobile is not at all densely populated.

For Denmark the overall kilometres resulting from the NTS is compared with the results from odometer reading of the car fleet for the years 2007-2011 (Christensen, 2013). This shows a 1-8% lower level of the kilometres with 4 of the 5 years in the upper end. A part of this difference is due to car kilometres from elderly people from 85 and up who are not included in the survey. But even with taking this into consideration the level of the car kilometres of the NTS is at least 5% too low. If this difference is due to a higher share of immobile than is the real case for Denmark it would end up with a level of the share of immobile at 12-13%. This might indicate that data collection methodology is the most important reason for the difference between Switzerland and Norway compared to the rest of the countries.

The sensitivity of the immobility rate to the data collection methodology, telephone calling scheme etc. is analysed in Christensen (2005 and 2006) based on the Danish NTS for 1998-2001. This shows that the immobile level is very sensitive to the data collection methodology.

Normally kilometres per traveller per day are used for planning in the countries. The comparison shows that the resulting level of this is very sensitive to a wrong level of the share of respondents without any trips. It is therefore important to assess the level of the share of immobile. The results therefore show a need for further research analysing the difference in the levels of immobile.

4.2.3 Travel indicators

Table 4.5 shows the resulting trip indicators kilometres, minutes and number of trips per traveller per day for the 13 surveys calculated as both absolute figures and as an index based on the mean travel distance. Kilometres per traveller are varying most between the countries, and trips per traveller are varying the least.

Barcelona has far the lowest number of kilometres per traveller with only 27 km per traveller. The time use and the number of trips per traveller is also the lowest. This is obviously because Barcelona is a city region and even a very dense city with short distances to ‘everything’. Berri et. Al. (2008), Ewing and Cervero, (2010) and Næss, (2005) show that people living in city regions and especially the dense

inner cities travel few kilometres per day. Spain is following with 33 km/traveller. For the Spanish survey 53% of the population live in metropolitan areas (OSE, 2007) which is a high share compared to most of the other countries and might also explain the low travel distances.

At the other end we find Sweden and Finland with the highest number of kilometres per traveller, more than 50. These are followed by Norway, the Netherlands and Denmark around 10% over the mean. The rest of the countries are travelling close to the mean with Great Britain and Switzerland in the low end. Interesting is also how close the results for the two German surveys are, the difference between the distance per traveller is 1.9 km, 1.3 min and 0.04 trips per traveller. Belgium has close to the mean kilometres per traveller, which is rather high taken into account that many shorter trips must have been left out with the high share of postulated non-travellers.

Table 4.5: Indicators of the travel activities shown as both absolute figures and as an index based on 100 = the mean level

				Index		
Country	**Km per Traveller**	**Time use per Traveller**	**Trips per Traveller**	**Km per Traveller**	**Time use per Traveller**	**Trips per Traveller**
Barcelona 06	26,5	62,7	3,08	60	78	87
BE 2010	44,5	74,4	3,35	101	92	95
CH 2010	43,4	96,0	3,89	98	119	110
DE Mid08	42,7	90,8	3,68	97	113	104
DE MOP06-10	44,6	89,5	3,72	101	111	105
DK 06-10	47,9	68,9	3,61	108	86	102
ES 2006	32,8[1]	74,6	3,24	74	93	92
Fi 10-11	52,3	80,5	3,49	118	100	98
Fr 07-08	45,0	78,4	3,64	102	97	103
GB 06-10	42,5	85,5	3,56	96	106	100
NL-06-09	49,0	79,0	3,62	111	98	102
NO 2009	49,1	85,7	3,83	111	107	108
SE 05-06	54,3	78,9	3,34	123	98	94
Mean	44,2	80,5	3,54	100	100	100

Note 1) Kilometres per traveller for Spain is an approximation.

The figures are leaving a picture of the rich Nordic countries travelling most. A high share of respondents living in metropolitan areas is reducing the aggregate travelled distances per traveller. A third partly explanation for differences is that Norway, Sweden, the Netherlands, France, and Belgium include international

trips whereas Spain, Great Britain, Denmark, and Finland have a limit at the border for the delivered tables (Denmark and Finland are able to calculate international travels too). The German Mid08 has a limit at 1,000 km and Barcelona only includes trips in the metropolitan area. There is a need for going deeper into the explanation of the differences based on the mentioned reasons and eventual other.

4.2.4 Indicators per traveller or per respondent

It was decided to calculate the indicators as kilometres, time use and trips per traveller instead of per respondent, which is normal. The hope is that the differences between the countries would be reduced and explanations for differences might be cleaned for the problems from data collection methods resulting in different shares of immobile. In Table 4.6 the two indicators are compared.

Table 4.6: Kilometres per traveller and per respondent in each of the participating surveys. The figures are shown both as absolute figures and as index based on 100 = the mean level

			Index	
	Km per Traveler	**Km per Respondent**	**Km per Traveler**	**Km per Respondent**
Barcelona 06	26,5	24,1	60	65
ES 2006	32,8	29,0	74	78
BE 2010	44,5	32,0	101	86
CH 2010	43,4	38,4	98	103
DE Mid08	42,7	38,3	97	103
DE MOP06-10	44,6	40,8	101	109
DK 06-10	47,9	40,0	108	107
Fi 10-11	52,3	43,1	118	116
Fr 07-08	45,0	37,0	102	99
GB 06-10	42,5	33,1	96	89
NL-06-09	49,0	40,5	111	109
NO 2009	49,1	42,8	111	115
SE 05-06	54,3	44,9	123	121
Mean	44,2	37,3	100	100

Calculating per respondent is not changing the relative level of the countries that much. The Nordic countries are still in the high end with Denmark a little lower than the rest. Respondents in Barcelona and Spain are travelling fewest kilometres. For Belgium and Great Britain the share of immobile is questioned above and the level is of course reduced pretty much. The two German surveys are now

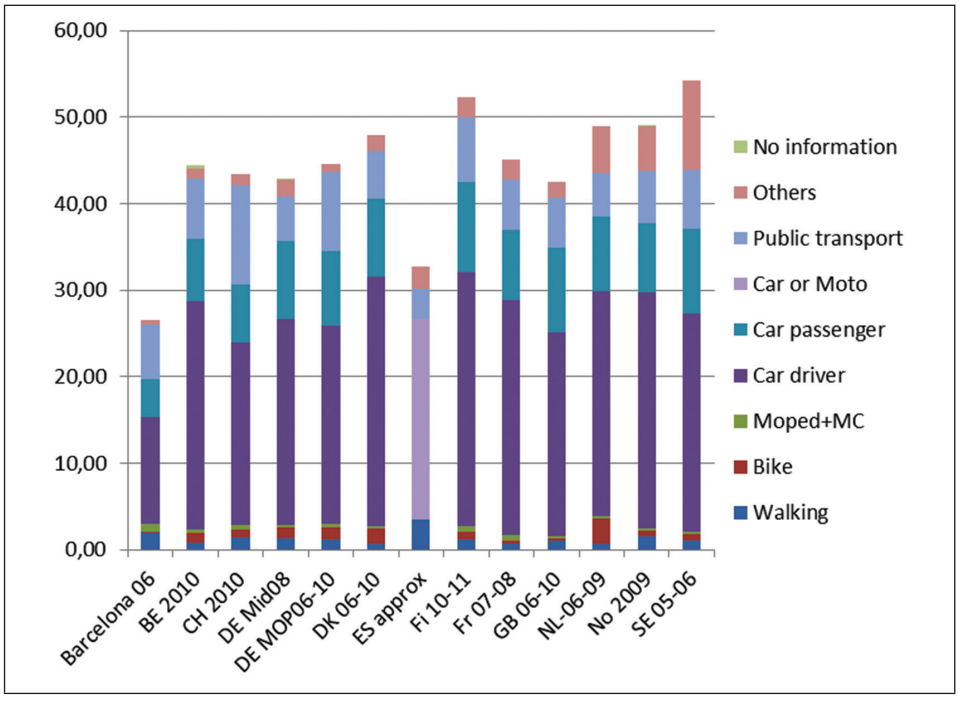
a good deal further from each other than they are by calculating kilometres per traveller. This could be an indication that the share of immobile in the MOP is too low as suggested above.

4.2.5 Mode share

Figure 4.2 showing the kilometres per traveller distributed on travel modes. Again the two German surveys are unusually close to each other in the mode share. The only difference is that public transport has a low share in the MiD08.

The 3 countries Sweden, Norway and the Netherlands, which includes international travels, have many kilometres by 'others', which is a mostly flight. If these were at level with the rest of the countries the kilometres per traveller would have been around the mean. At the other hand France and Belgium, which also includes travels abroad, do not have a high share of 'others'. The Belgian figures are very uncertain so they might not be trusted too much. Opposite to France for which the international travels doesn't seem to count so much. Barcelona also has too many travels, as 'others' because vans are by a mistake categorised as 'others' instead of car driver or passenger – there is no flight travels inside the city region.

Figure 4.2: Kilometres per traveller distributed on travel modes



Note Kilometres per traveller for Spain is an approximation.

Countries with many kilometres per traveller all have more car kilometres as driver. Spain and especially Barcelona at the other hand has few kilometres by car in all as both drivers and passengers. Switzerland has much more kilometres by public transport than the rest of the countries.

What are interesting too to observe from Figure 4.2 are the walking and bike trips. For many countries the sum of walking and bike kilometres is very close to each other. Denmark has more bike kilometres but less walking; in Norway, Switzerland, and Germany they walk a little more. Finland, Sweden, and Belgium is also close at but with less bike kilometres. The countries, which are clearly different, are the Netherlands with many bike kilometres and Spain and Barcelona with many walking kilometres. In Great Britain and France they neither walk nor bike much.

From Figure 4.3, which shows the time use distributed on travel modes it can be seen that it is first of all walking, that increases the time use. The countries with long travel distances use less time on travelling because a higher share of kilometres is done by the fast modes, car and 'others'. Barcelona and especially Spain use relatively more time on travelling than the distances travelled.

Figure 4.4 makes the picture even clearer. The number of trips is close to the same in all surveys. The countries that travel many kilometres are travelling more trips by car.

Figure 4.3: Time use per traveller distributed on travel modes

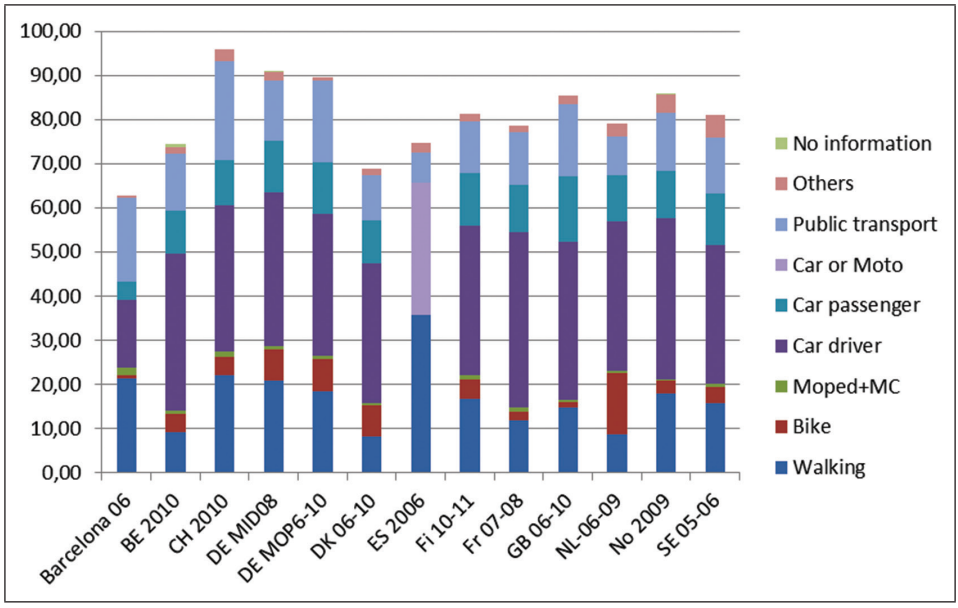
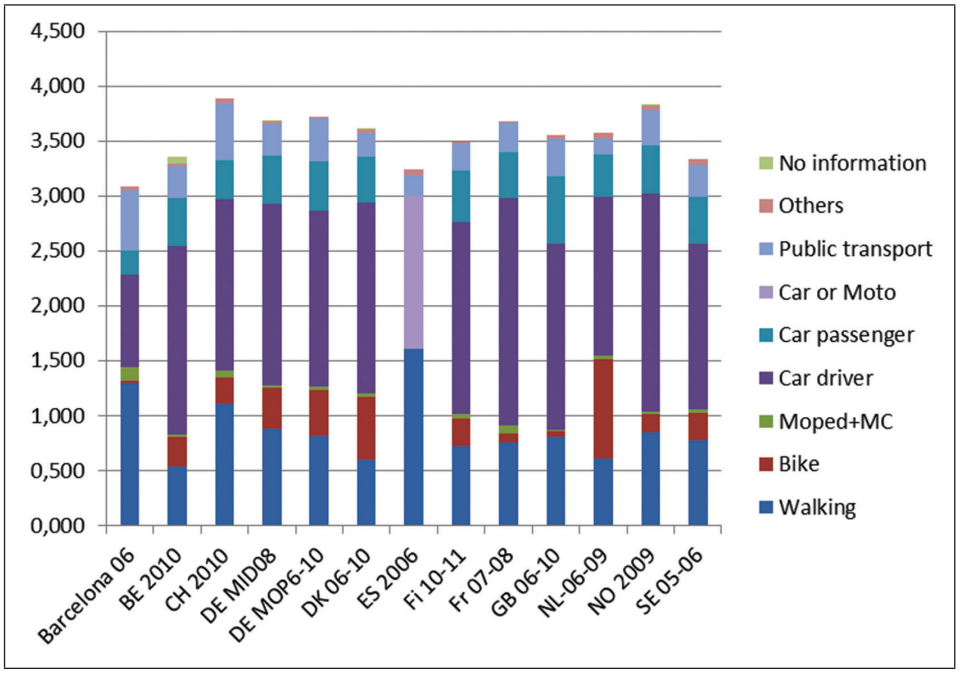


Figure 4.4: Number of trips per traveller distributed on travel modes



4.2.6 Travel distances

Figure 4.5 is showing the distribution of kilometres on trip distances. For trips up to 50 km the kilometres per traveller is rather similar. There is a tendency to a little fewer kilometres at these shorter trips for the countries with many kilometres, especially Norway, Sweden, and the Netherlands. This is opposite the case with Belgium and France, but also Denmark has more kilometres at the distances up to 50 km. The 4 countries with most kilometres have many kilometres at trips over 1000 km. Except for Finland it is also the countries with international travels. France and Belgium have less long travels that are in accordance with the medium level of kilometres with others above. Again the picture for the two German surveys is very similar. In Barcelona trips at all distances over 5 km are less frequent than the rest of the countries.

Figure 4.6 is showing number of trips by the three slow modes. Mopeds and motorbikes are used very little. Most people are walking in all countries except from the Netherlands. Most trips by foot is less than 2 km. Switzerland, Norway and Barcelona have more trips longer than two kilometres than the rest of the countries. As mentioned above Dutch people are biking much more than all others. And much more at longer distances than 2 km. Danes are after and Germans close to the Danish level. About the same number of trips are shorter and longer than 2 km.

Figure 4.5: Distribution of kilometres per traveller on trip distances

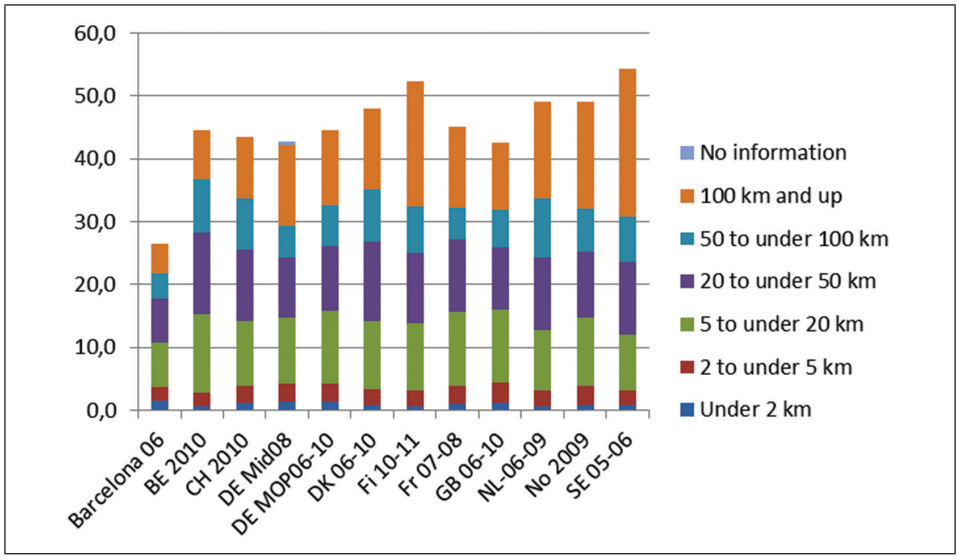
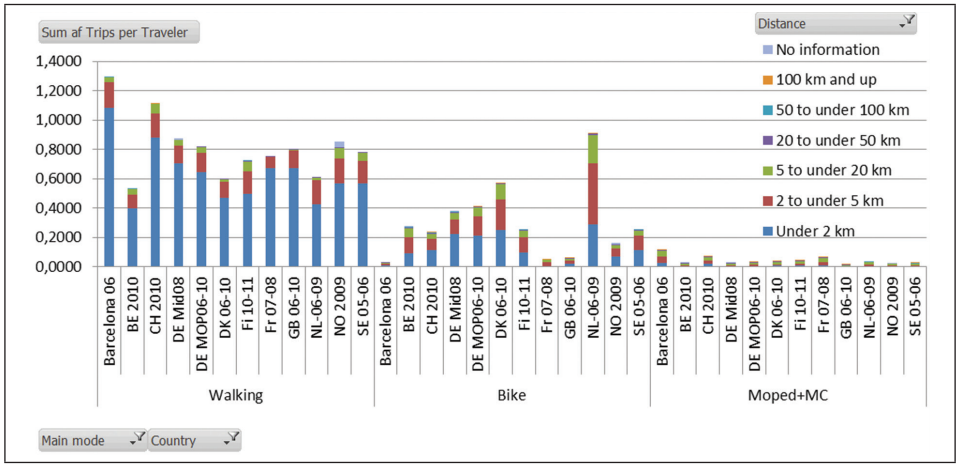


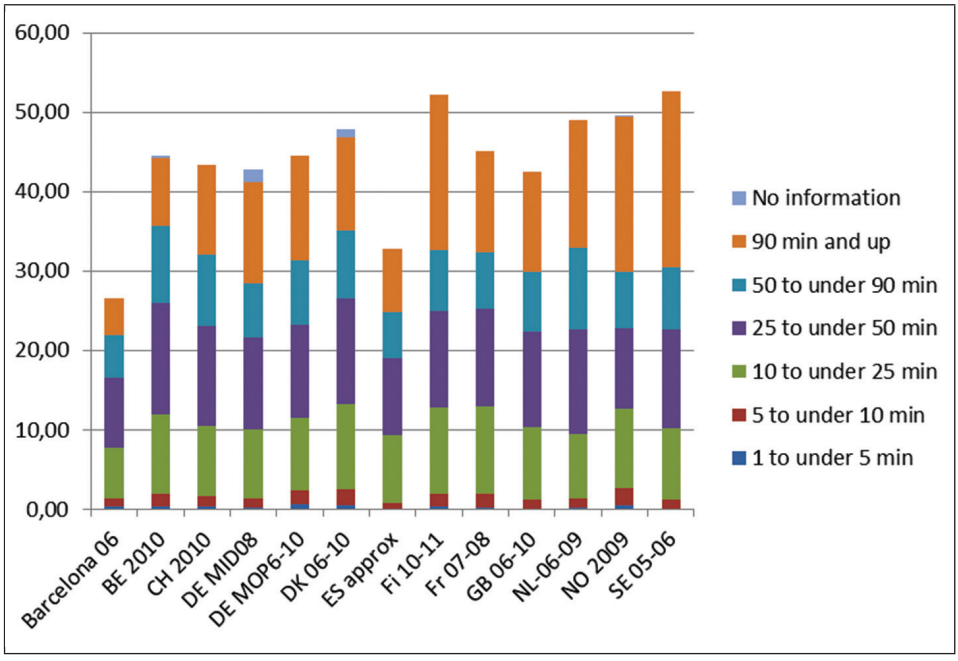
Figure 4.6: Number of trips per traveller at different distance bands by 3 modes



4.2.7 Time use bands

Figure 4.7 is showing the distribution of the travel distance per traveller on time use bands. The most interesting is that Denmark and partly Belgium has more kilometres in all time use bands up to 50 minutes than the rest of the countries. In a table, in Appendix F: Calculation of estimated kilometres per traveller per day for Spain, it can be seen that it is the case at all distances by all modes. It seems to have something to do with the data collection method, eventually because of real time control of most of the stated distances in the interview in Denmark. An on-going analysis in Denmark with comparing un-controlled distances from the years 2006-07 with controlled figures from the following years seems to show that the controlled distances, which are changed, are 30% longer than the un-controlled distances.

Figure 4.7: Distribution of kilometres per traveller on time use bands



Note Kilometres per traveller for Spain is an approximation.

4.2.8 Estimation of kilometres per traveller for Spain

As mentioned, Spain has not been asking for trip length in the questionnaire. However, with information about travel distances from all other countries it has been possible to estimate a good approximation to the travel distance per traveller distributed at modes and at time use bands.

For each time use band the mean travel distance for each transport mode has been found for all countries. Barcelona has very different mean travel distances from the other countries and data from GB was not received yet so they are kept out. For the rest of the countries a mean distance is calculated. For all time use bands and all modes this mean distance is multiplied by the trip frequency calculated from the table for Spain for the respective time use band and mode.

However, Spain has not the same modes in the survey as the rest of the countries. Walking and bike are together and car drivers and passengers are together with moped and motorcycle (MC). The mean distances for these groups had to be estimated too which again was based on an assessment of the distribution of the rest of the countries. For the distribution of trip frequency on bike and walking France is used. Based on France 95% of the cycling and walking trips less than 5 minutes are expected to be done by foot. The share of the cycling and walking trips done by foot is falling to 80% for trips longer than 1½ hour. Based on several countries including France and Barcelona only 3% of the trips by car and moped are at moped or motorcycle for all distances. Trips by car as driver are except for the longest duration trips a little longer than passenger trips. For the shortest distances 95% of the car and moped trips are driver trips. The chosen share is falling to 70% for the longest trips. This is based on frequencies from several countries.

The result is 32.8 km per traveller per day. The exact choice of the mean distance based on the frequencies of trips at different modes has only very marginal effect on the overall kilometres per traveller. Changing from an equal distribution on walking and biking and on moped and the two kind of car trips to the chosen distribution the kilometres per traveller is decreased from 32.9 km to 32.8 km per traveller. With all trips by walking and bike taken as walking trips respectively an average of car driver and car passengers is resulting in 32.1 km per traveller. By including Great Britain in the mean distances kilometres per traveller is falling from 32.8 to 32.7 km.

The results of the approximation of the Spanish travel distances are included in the tables and figures in the chapters above. As for Barcelona the number of kilometres in all time use bands are fewer than the rest of the countries (Figure 4.7)

4.2.9 Travel purpose and weekday

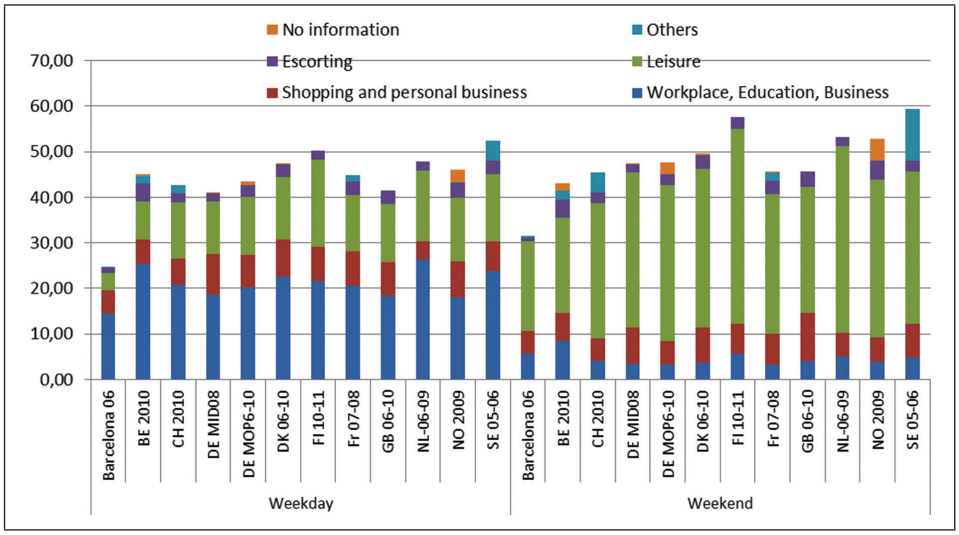
Travel distance per traveller is shown in Figure 4.8for weekdays and in weekends distributed at travel purpose. Commuting and work-related travels and education is of course most common on weekdays. Belgium and the Netherlands have more of these than other countries at weekdays and Belgium furthermore more in weekends. Both countries include cross border travels so longer commuting trips in mean might eventually be explained by travels to Luxemburg and the German cities along the Rheine. But the long weekend commuting for Belgium seems suspicious and might point to an explanation related to the high share of immobile; perhaps many sampled respondents do not participate when they don't have a commuting trip. Great Britain has less commuting than other countries

which is also found in a commuting statistic for the country (Nielsen, Hovgesen and Lassen (2005)) See Appendix E: Figures of post-harmonisation of data from National Travel Surveys across Europe.

The Netherlands has less shopping than other countries at weekdays. This could be related to the urban structure with more local shops and with many cycling trips. Great Britain is at the other end with longer shopping trips in the weekends. This might be related to a shopping structure with more decentralised big shopping centres than in the rest of Europe.

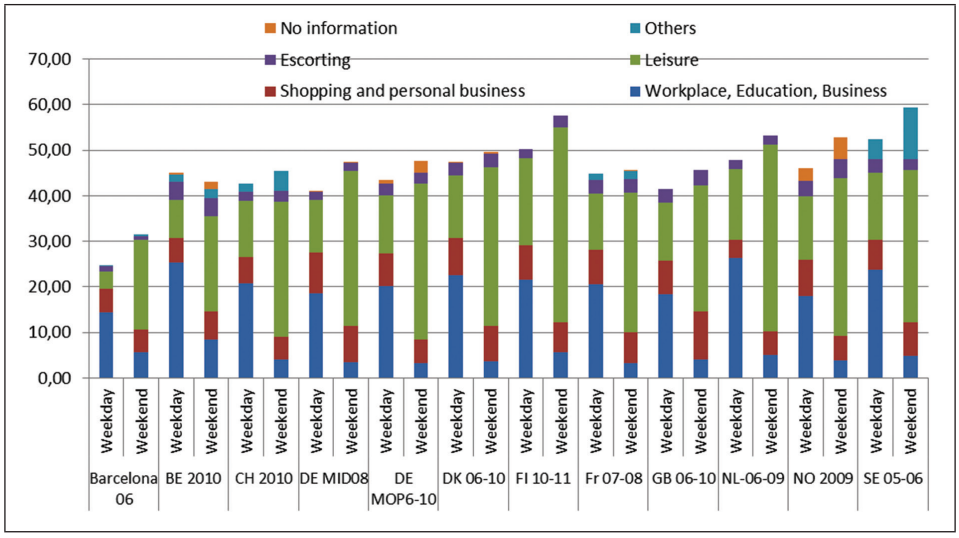
Leisure trips are at the same level in weekdays for all countries except Barcelona. Finland and partly the Netherlands have longer leisure trips in the weekends. For Finland the explanation might be visits at summer cottages in the nature in weekends. Leisure trips at workdays are also in the high end, which might be explained by Friday trips to these summer cottages.

Figure 4.8: Kilometres per traveller at weekdays and in weekends for purposes for 12 surveys



In Figure Figure 4.9 the same is shown but the columns are reorganised so it is easier to compare weekdays and workdays. It can be seen that for all countries except Belgium respondents are travelling longer in weekends than at workdays. The biggest differences are found in Barcelona, Finland and Sweden. Unfortunately Sweden has a big group with the purpose 'others'. If this is a leisure trip the explanation could be the same as for Finland, visits at summer cottages. For Norway there is a big group of no information if this is a leisure trip we can see the same pattern. Denmark has many summer cottages too but they are often located closer to the home, typically 5-50 km away. Leisure trips in Denmark are therefore more at level with the rest of the countries in which people travels to the open nature and for instance stay at hotels.

Figure 4.9: Kilometres per traveller for 12 surveys arranged for weekdays and weekends side by side



4.2.10 Car-ownership

Figure 4.10 is showing kilometres per traveller and mode share for respondents without car or with one or more cars. For some of the surveys the results are also shown for different family types. Not all surveys have been able to deliver data on the chosen family types and are therefore only included for the car-ownership groups. Barcelona has not been able to differentiate between one and more cars in the household. Singles with more than one car are left out thanks to very few respondents.

The variation between the countries is much bigger than seen above due to much smaller groups. Only few remarkable results should be mentioned because most of the differences might very well be explained by uncertainties.

The first result is that families without children are travelling fewer kilometres than families with one car and they are again travelling fewer kilometres than families with 2 or more cars. This conclusion is the case for all family types and for all countries.

Car ownership is of course also influencing the mode share. Families without a car are travelling more kilometres by public transport and by bike than car-owning families. Especially in Switzerland the public transport kilometres per traveller is very high for families without car. For families with one car it is also higher but for families with two cars the kilometres by public transport are at level with the rest of the countries. For all three car-owning groups respondents in the Netherlands are travelling more kilometres on bike than people from other countries.

Families without a car are driving very little by car as driver but a little more as car passenger. Especially in Switzerland car is very little used in families without car. The opposite is the case in Denmark for which much more family's borrow/ rents a car or are brought as passengers by other people.

Singles with one car are travelling more kilometres than other family types with one car including singles with children. They drive most by car as drivers and only little as passengers. For couples and families driving a car is much less common than for singles. Car passenger is an important mode. Only in Switzerland public transport is used for many kilometres.

For couples and families with children with two or more cars car driving is of course the most common transport mode. However, they still drive much as passengers, the level is close to the same as for families with one car. In Denmark and Finland and partly Norway respondents with two cars are travelling more kilometres than in other countries. In these countries a car is more expensive than for the rest of the countries. At least in Denmark it is known that families who afford to have two cars really need the second car. In mean the two cars are each driving as much as the car in a one-car household the extra travel activity is therefore done by car as driver.

5 Data Needs

5.1 Introduction

Although, an extensive literature is available concerning the design of travel surveys, fewer research initiatives yet have been carried out to determine the content of the survey itself. The most noteworthy effort in this regard is the NHCP report 571 (Stopher et al., 2008)[1] that outlines the framework for a standardization of procedures for carrying out national travel surveys. Nonetheless, this report does not explicitly address which questions should be minimally asked in a national household travel survey (NHTS). To this end, a questionnaire was designed to elicit which questions should be minimally in a NHTS. Moreover, it is investigated whether unanimity exists in the experts' opinions concerning the importance of various types of questions and whether regional and/or professional differences exist.

The remainder of the chapter is organized as follows. First, the expert survey is discussed. Consequently, the methodology is outlined and the results are presented. Finally, a discussion and conclusion is provided.

5.2 Expert survey

5.2.1 Set-up of the MTSQ survey

The goal of the Mini-Travel Survey Questionnaire (MTSQ) survey is to elicit travel survey experts' opinions on the importance of the various questions that are part of NHTS. The MTSQ questionnaire was divided into four parts. The first part contained questions concerning the professional profile of the experts and of the agencies they are affiliated with. The second part assesses the importance of questions, which are related to the household (HH), and their two- and four-tier vehicle possession [HH1-HH3]. The third part mainly focused on the importance of various person-related aspects such as socio-demographic characteristics, geographical information about the home location and the usage of transport modes [PER1-PER3]. The fourth and final part was devoted to assess the necessity of various aspects of the trip diary [TRIP].

The majority of the questions to assess the importance of questions in a travel survey were ERSNO (Essential, Recommended, Secondary, No Opinion) questions. The following specific definition was used to define this ordinal scale:

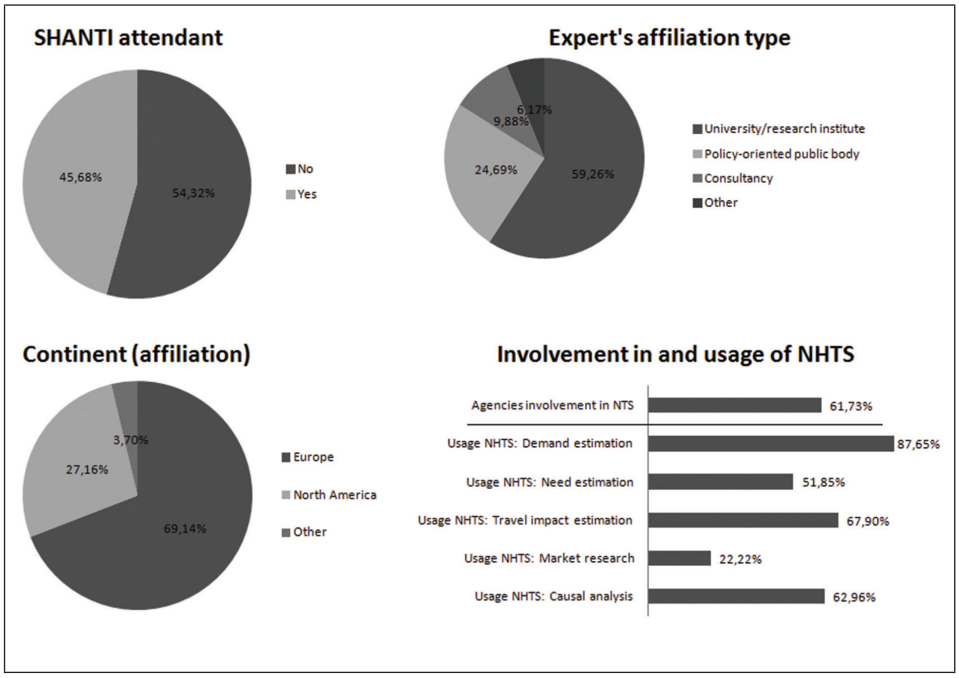
1. Essential: it should be part of every national travel survey no matter what;
2. Recommended: the item is recommended for methodological/analytical issues (e.g. weighting);
3. Secondary: not essential and not (absolutely) required for methodological/analytical issues.

[1] *http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_571.pdf*

5.2.2 Description of the response

The MTSQ survey was completed successfully by 81 respondents in October-November 2012. Figure 5.1 provides an overview of the descriptive statistics of the respondents. The pie graph concerning the SHANTI attendance reveals that the respondents were well balanced between survey experts that took part of the SHANTI project and survey experts who had no involvement with the project. With regard to the affiliation type of the experts, it could be noted that that about 60% of the experts were working at a university of research institute, and about one quart for a policy-oriented public body. With respect to the geographical spread of the experts, it could be depicted that about 70% of the experts are affiliated with an organization based in Europe. The other experts are mainly based in Northern America. The large share of European experts is mainly due to the fact that the SHANTI project is a European project, and that policy recommendations based on the project results in first instance must be formulated in a European context. Notwithstanding, in the analysis of the results, explicit attention will be paid to potential differences between European and North American experts. Finally, the figure provides insight into the experts' agencies involvement and usage of the NHTS. The majority (about 62%) of the agencies of the experts was involved in the NHTS (either through the design, fieldwork or the official analysis) and the main use by the experts of the NHTS data was for demand estimation.

Figure 5.1: Descriptive graphs of the experts' characteristics



5.3 Methodology

Recall that the main objective of this paper is to investigate which questions are considered as essential elements of national travel surveys, and to assess which factors of the experts' professional profile are influencing these results.

To determine which questions are considered as essential the following prioritization (weighting) scheme was used on the 92 ERSNO (Essential, Recommended, Secondary, No Opinion) questions. (See Table 5.19)

Table 5.1: Prioritisation weights

Ordinal assessment	Weight
Essential	5
Recommended	2
Secondary	1
No opinion	0

The respective share of respondents multiplies the weights in the above table, in order to give a total score that expresses the degree of essentialness of each question. Let be the share (expressed in%) of experts that find question i essential, the share that recommend this question to be included, the share that regard is as secondary, and the share that has no opinion on question i, then the score Si for question i is calculated as , having a minimum score of 0 and a maximum score of 500. Table Y gives an overview of some possible combinations of the different shares. Questions with a score higher than 400, are considered as the key essential questions. This value of 400 corresponds to 70% finding the question essential (and a large enough share of the remaining 30% either recommends the question or considers it as a secondary question). Questions with a value above 350 are considered highly recommend (moderate essential) questions Table 5.2 provides an overview of possible distributions of the ordinal assessment shares with their corresponding score statistics. Note that in the calculations these score statics can be tabulated from a global perspective (all respondents pooled together) or by subgroup (e.g. the score of the Europeans and North Americans).

Table 5.2: Illustration of the rank score computation

Essential%	Recommended%	Secondary%	Score
100	0	0	500
90	0	10	460
80	10	10	430
70	20	10	400
60	30	10	370
50	50	0	350
40	50	10	310

Next to the overall assessment of the degree of essentialness of various questions in a NTHS, the effect of the experts' professional profile on this assessment is elucidated. To this end, two types of analysis are carried out. At a more aggregate level, the impact of the experts' characteristics on the essentialness of the different questionnaire blocks is assessed by means of Poisson regression. Secondly, at the level of individual questions, the dependency of the response (in most instances essential or not essential) was assessed using Fisher's exact test. When computation times exceeded a clock time of 200 seconds, Monte Carlo estimation of the exact p-values was used instead of the direct estimation. The choice for exact tests rather than typical Pearson chi-square tests was made as the basic assumptions of the latter test (80% of the expected cell frequencies larger or equal than 5) was likely to be violated, whereas the exact computations did not rely on parametric assumptions.

5.4 Results

5.4.1 Overall assessment essentialness of questions

See Appendix D: The Data Needs questionnaire

Table 5.3 provides an overview of all the questions that were highlighted either (values above 400) as essential or highly recommended (values between 350 and 400). The table is organized according to the question block and the world score. In addition, the scores for the experts from Europe and North America are tabulated as well. From this Table, it becomes clear that next to a multitude of trip-related attributes, especially the socio-economic profile of the household and individual are regarded as essential, as well as the access to and use of different transport modes. Table 5.4 displays the attributes that are esteemed to have a lower priority. Stage-related travel information, characteristics of the dwelling, household vehicles and parking facilities are indicated as less essential.

Table 5.3: Rank-scores for the essential and highly recommended questions

Block	Question	World	Europe	N.-America
HH1	Age/date of birth of the HH-members	471,61	471,42	468,20
HH1	Number of persons with the HH	466,67	462,50	472,73
HH1	Gender of the HH members	453,12	462,50	422,72
HH1	Occupation (active/non-active) of the HH-members	448,15	455,34	422,72
HH1	Date of the survey (YYYY/MM/DD)	445,67	426,79	500,00
HH1	Net household income (predefined categories)	380,26	348,24	459,08
HH1	Type of non-activity (e.g. retired, student,) of the HH-members	370,37	374,97	368,18

Table 5.3: Rank-scores for the essential and highly recommended questions (suite)

Block	Question	World	Europe	N.-America
HH1	Work regime (full-time, part-time,) of the HH-members	359,29	330,36	427,26
HH3	Number of cars with the HH	456,79	442,85	486,35
PER1	Age / date of birth	475,30	483,92	449,99
PER1	Gender	464,20	473,21	436,37
PER1	Driving license for private vehicles (Y/N)	445,68	451,77	422,72
PER1	Possession of a PT card (season ticket/transit pass)	406,17	405,35	395,45
PER1	Importance Relation to the reference person (Spouse, child,...)	364,20	337,47	413,66
PER2	Domicile for the travel day: geographical information	430,84	416,07	472,73
PER2	Domicile for the travel day: (not) at home	429,61	423,23	436,38
PER2	Domicile for the travel day: street of the domicile	350,63	294,64	486,35
PER3	Frequency of travelling by car as driver	386,43	398,19	368,21
PER3	Frequency of travelling by bus	379,02	392,87	354,54
PER3	Frequency of travelling by car as passenger	377,79	392,87	350,00
PER3	Frequency of travelling by tram	376,56	389,29	354,54
PER3	Frequency of travelling by train	376,56	389,29	354,54
PER3	Frequency of traveling by foot	369,14	378,60	354,54
PER3	Frequency of travelling by bike	369,14	383,92	340,94
PER3	Frequency of travelling by moped/ motorcycle	353,06	371,43	313,63
TRIP	Departure point of the trip	479,03	469,63	500,00
TRIP	Destination point of the trip	475,29	464,31	500,00
TRIP	Main transport mode of the trip	470,37	457,15	500,00
TRIP	Departure time of the trip	464,21	448,23	500,00
TRIP	Arrival time of the trip	448,14	430,36	486,35
TRIP	Trip purpose (generic, e.g. list of 10 purposes)	434,57	442,85	404,56
TRIP	For each stage within the trip: transport mode	390,15	367,84	445,46

Table 5.4: Rank-scores for the remaining (non-essential, non-highly recommended) questions

Block	Question	World	Europe	N.-America
HH1	Educational background of the HH-members	328,40	330,34	313,62
HH1	Type of occupation (e.g. blue vs white-collar worker) of the HH-members	295,07	296,43	290,88
HH1	Dwelling/housing type	262,94	248,24	300,00
HH1	Dwelling/housing ownership	219,75	203,56	254,52
HH1	Internet connection (Y/N)	207,40	196,42	227,27
HH1	Landline telephone availability (Y/N)	190,10	164,28	245,43
HH2	Number of mopeds/motorcycles within the HH	308,64	319,63	268,17
HH2	Number of bicycles within the HH	271,61	289,29	209,12
HH2	Mileage last 12 months of the moped/ motorcycle	211,13	237,50	145,47
HH2	Total mileage of the moped/motorcycle	170,40	182,14	136,38
HH2	Year of construction of the moped/ motorcycle	150,61	158,93	131,81
HH2	Power of the engine of the moped/ motorcycle	140,75	157,16	104,58
HH2	Year of purchase of the moped/motorcycle	140,73	146,42	122,76
HH2	Cylinder capacity of the engine of the moped/motorcycle	139,49	153,56	109,12
HH2	Type/model of the moped/motorcycle	122,23	126,82	113,66
HH2	Brand of the moped/motorcycle	113,59	107,14	131,82
HH3	Availability of the car (fully/partially available)	328,40	317,85	345,47
HH3	Energy source of the car	324,70	332,14	295,46
HH3	Importance Total mileage for the last 12 months of the car	311,09	328,55	254,55
HH3	Category of car (e.g. car, delivery van, camper, other)	275,28	260,73	295,44
HH3	Year of construction of the car	259,24	275,02	222,74
HH3	Options for parking the car during the night (e.g. in the street)	254,34	257,14	245,43
HH3	Year of purchase of the car	234,59	212,49	286,36
HH3	Type/model of the car	232,11	203,56	286,34
HH3	Costs for parking the car during the night (e.g. free)	220,97	185,71	290,91
HH3	Cylinder capacity of the engine of the car	192,60	196,42	159,09

Table 5.4: Rank-scores for the remaining (non-essential, non-highly recommended) questions (suite)

Block	Question	World	Europe	N.-America
HH3	Power of the engine of the car	190,11	201,78	149,99
HH3	Brand of the car	167,89	141,08	227,29
HH3	Method of acquisition of the car (e.g. new/2nd hand/company)	164,21	166,07	150,00
HH3	Fiscal/taxable power of the engine of the car	149,38	151,79	150,00
PER1	Main occupation (e.g. blue-collar, white-collar, student,...)	348,16	351,78	331,82
PER1	Educational background	344,46	357,15	290,91
PER1	Other occupation (worker/student/not applicable)	319,74	332,13	277,28
PER1	Work flexibility (fixed hours, flexible hours)	287,66	276,81	313,62
PER1	Number of working hours / week	276,55	255,37	313,64
PER1	Work regime (night, day, shifts,...)	259,29	253,60	268,19
PER1	Number of years holding driving license for private vehicles	240,74	250,01	200,01
PER1	Mobile phone owned for personal use (Y/N)	198,74	176,78	231,83
PER1	Additional information about workers	197,51	178,58	231,81
PER1	Mobile phone owned for professional use (Y/N)	171,63	157,12	195,47
PER1	Personal email consulted at least once a week (Y/N)	167,93	166,06	159,09
PER1	Professional email consulted at least once a week (Y/N)	151,86	142,87	159,09
PER2	Domicile for the travel day: full address of the domicile	333,33	282,14	472,73
PER2	Domicile for the travel day: parking possibilities	304,97	266,08	377,30
PER2	Domicile for the travel day: parking costs	282,71	228,56	390,90
PER3	Frequency of travelling by taxi	340,74	337,48	354,54
TRIP	Self-reported trip distance of the trip	335,82	357,15	272,71
TRIP	For each stage by car as driver: number of occupants	328,38	298,21	399,99
TRIP	For each stage within the trip: departure point	319,73	278,55	413,66
TRIP	For each stage within the trip: destination point	312,32	267,84	413,66

Table 5.4: Rank-scores for the remaining (non-essential, non-highly recommended) questions (suite)

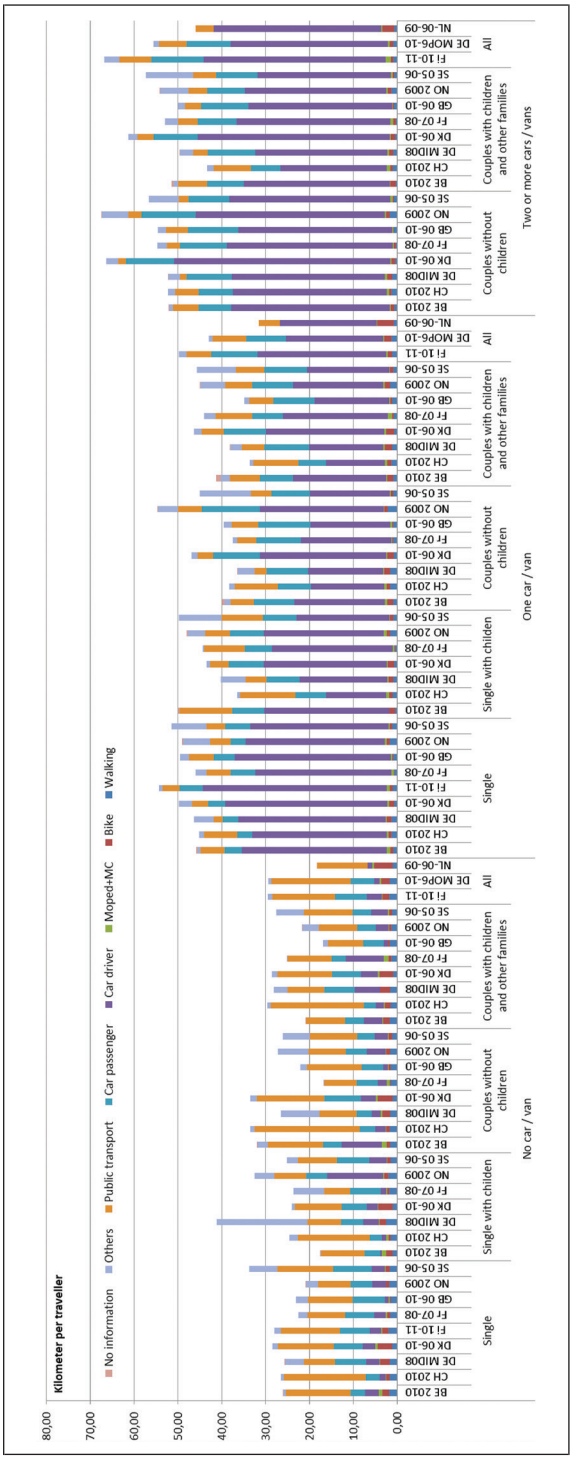
Block	Question	World	Europe	N.-America
TRIP	For each stage within the trip: duration	304,96	282,12	363,63
TRIP	For each stage within the trip: departure time	301,24	258,91	395,45
TRIP	For each stage within the trip: arrival time	301,24	258,91	395,45
TRIP	Bearing of the costs of the trip (full, partly, none)	260,51	216,06	354,55
TRIP	Trip purpose (very detailed, e.g. list of 40 purposes)	251,88	237,47	295,44
TRIP	For each stage within the trip: self-reported distance	246,90	246,40	240,89
TRIP	For each stage by car as driver: parking costs	240,77	189,29	354,56
TRIP	For each stage by car as driver: specification of the car	239,50	217,87	290,92
TRIP	For each stage by car as driver: type of parking place	237,04	196,45	322,71
TRIP	For each stage by car as driver: parking search time	217,29	194,66	254,57

5.4.2 Influencing factors

Recall that next to the overall assessment of essentialness, the influence of the experts' professional profile on this assessment is assessed. At an aggregate level, it is investigated how the different attributes of the experts' professional profile affect the number of ERSNO questions that are considered as essential. Poisson regression models were developed to estimate the impact on the total number of questions, as well as to estimate the impact on the number of questions per question block. The models predicting the total number of questions provide insight on differences in the overall necessity of questions, i.e. the size of the potential minimum (essential) NHTS. The analysis at the block level is required as the analysis of the total number of questions might hide fundamental differences, which are present at the block level. After all, different blocks might counterbalance the overall assessment. Table 5.5 provides the p-values of the significance tests of the influence of the characteristics of the expert's profile of the 72 different Poisson models. The parameter estimates of these models are presented in Table 5.6.

From Table 5.5 it can be seen that, at the overall assessment of essentialness significantly depends on the continent, the involvement in the NHTS, and the use of the NHTS for demand estimation, market research and causal analysis. From Table 5.6, one can observe that North American experts appear to consider 17.4%

Figure 4.10: Kilometres per traveller for car-ownership and family type for 11 surveys



more questions as essential when compared to their European counterparts. This is also supported Figure 5.2 that relates the share of European and North-American experts to the percentage of questions that are considered essential by these experts. Besides, the use of the NHTS for demand estimation and causal analysis result in an evaluation of respectively 15.4% and 8.4% more questions as essential. In contrast, active involvement in the NHTS survey process and the use of the NHTS for market research decreases the number of questions marked as essential by 11.8% and 9.1%.

With respect to the first block of household questions, only one aspect of the expert's profile plays a role, namely the use of the NHTS for causal analysis: when the expert uses the NHTS for causal analysis, he or she esteems 14.9% more questions as essential. In contrast to the first block of household questions, the expert's profile plays a significantly larger role in the second block of the household questionnaire. European experts are attributing considerably more weight to this type of questions in comparison to their North-American counterparts, as the latter consider 45% questions less as important. With respect to the other questionnaire blocks, the most striking difference is the difference between European and North-American experts with respect to the assessment of the second block of person questions (geographical information about the home location): North-American experts evaluate on average 68.7% more questions as essential.

Table 5.5: P-values of the Type III significance tests of the Poisson models predicting the number of essential questions*

Expert's profile	ALL	HH1	HH2	HH3	PER1	PER2	PER3	TRIP
SHANTI attendance	0,967	0,488	***0,020***	0,547	0,354	0,619	0,772	0,163
Affiliation type[1]	0,789	0,831	***0,028***	***<0,001***	0,534	0,782	***0,030***	0,222
Continent[2]	***<0,001***	0,124	***0,018***	0,193	0,836	***<0,001***	0,281	***<0,001***
NHTS involvement	***<0,001***	0,943	***0,042***	0,540	0,968	***0,002***	0,726	***<0,001***
NHTS use: demand estimation	***0,010***	0,396	0,179	***0,058***	0,405	0,266	0,878	0,172
NHTS use: need estimation	0,133	0,768	***0,049***	0,774	***0,066***	0,654	***0,006***	0,572
NHTS use: impact assessment	0,210	0,488	***<0,001***	***0,007***	0,518	0,951	0,344	0,300
NTHS use: market research	***0,026***	0,167	0,543	0,716	0,251	0,849	***0,027***	0,943
NTHS use: causal analysis	0,027	***0,098***	0,983	0,984	***0,074***	0,859	***0,009***	0,736

*Bold italic values indicate significant effect (level of significance of 10%)

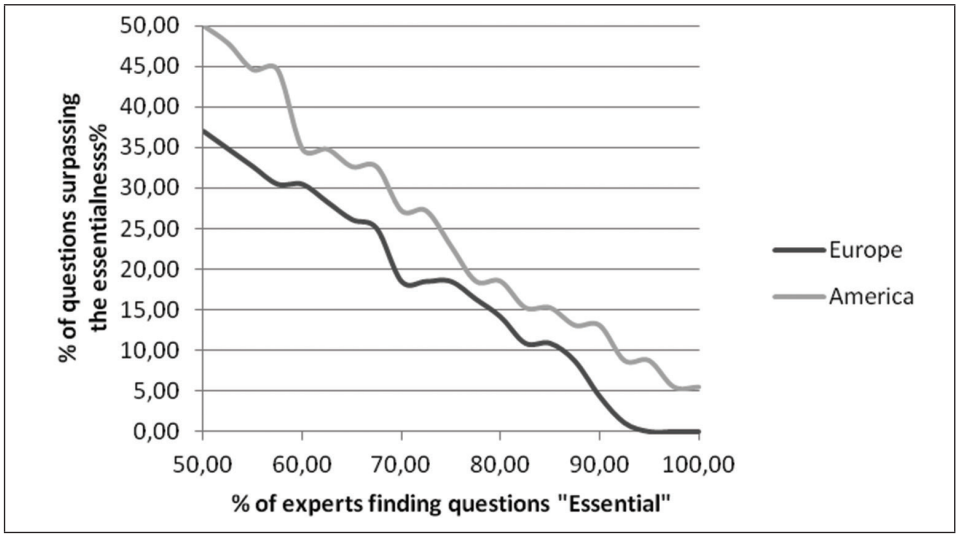
1 For the effect size estimation of the continent only the responses Europe and North-America were taken into account

2 For the effect size estimation of the affiliation type only universities, policy bodies and consultancy agencies were taken into account

Table 5.6: Parameter estimates of the Poisson models predicting the number of essential questions

Block	Expert's profile	Level	Est.	S.E.	Mult. Eff.
ALL	Continent	North America (vs Europe)	0,160	0,038	+17,4%
ALL	NHTS involvement	Yes (vs No)	-0,126	0,035	-11,8%
ALL	NHTS use: demand estimation	Yes (vs No)	0,143	0,056	+15,4%
ALL	NTHS use: market research	Yes (vs No)	-0,096	0,043	-9,1%
ALL	NTHS use: causal analysis	Yes (vs No)	0,080	0,036	+8,4%
HH1	NTHS use: causal analysis	Yes (vs No)	0,139	0,084	+14,9%
HH2	SHANTI attendance	Yes (vs No)	0,445	0,192	+56,1%
HH2	Affiliation type	Consultancy (vs University)	-0,993	0,461	-63,0%
HH2	Continent	North America (vs Europe)	-0,599	0,253	-45,0%
HH2	NHTS involvement	Yes (vs No)	0,426	0,210	+53,1%
HH2	NHTS use: need estimation	Yes (vs No)	0,384	0,195	+46,8%
HH2	NHTS use: impact assessment	Yes (vs No)	-0,695	0,190	-50,1%
HH3	Affiliation type	Policy (vs University)	-0,526	0,140	-40,9%
HH3	NHTS use: demand estimation	Yes (vs No)	0,346	0,183	+41,3%
HH3	NHTS use: impact assessment	Yes (vs No)	-0,291	0,108	-25,2%
PER1	NHTS use: need estimation	Yes (vs No)	0,151	0,082	+16,3%
PER1	NTHS use: causal analysis	Yes (vs No)	0,155	0,087	+16,8%
PER2	Continent	North America (vs Europe)	0,523	0,124	+68,7%
PER2	NHTS involvement	Yes (vs No)	-0,373	0,119	-31,1%
PER3	Affiliation type	Policy (vs University)	0,281	0,106	+32,4%
PER3	NHTS use: need estimation	Yes (vs No)	0,260	0,095	+29,7%
PER3	NTHS use: market research	Yes (vs No)	-0,272	0,123	-23,8%
PER3	NTHS use: causal analysis	Yes (vs No)	0,264	0,102	+30,2%
TRIP	Continent	North America (vs Europe)	0,362	0,072	+43,6%
TRIP	NHTS involvement	Yes (vs No)	-0,356	0,067	-30,0%

Figure 5.2: The share of experts in relation to the percentage of questions that are considered essential by them



Next to the dependency of the response was assessed using Fisher's exact test. Table 5.7, provides the information of the questions that were queried in addition to the ERSNO questions. From this Table it becomes clear that North-American experts put a larger accent on querying all members of the household, and desire a more precise level of geographical detail in the trip diary.

Table 5.7: Dependency of the non-ERSNO questions on the region of the expert

Response	Europe	N.-America
Household members to be surveyed (p-value Fisher's exact test: 0,0141)		
All household members	58,93%	95,45%
All adults and selection of children	14,29%	0,00%
Selection of adults and children	12,50%	0,00%
Adults only	10,71%	0,00%
No opinion	3,57%	4,55%
Number of mopes/motorcycles to be queried (p-value Fisher's exact test: 0,3420)		
Number of cars to be queried (p-value Fisher's exact test: 0,3328)		
Average trip frequency per mode: numerical vs ordinal (p-value Fisher's exact test: 0.2976)		
Average trip frequency per mode: Mo-Fr vs entire week (p-value Fisher's exact test: 0.0821)		
Workdays (Mo-Fr)	19.64%	40.91%

Table 5.7: Dependency of the non-ERSNO questions on the region of the expert (suite)

Response	Europe	N.-America
All seven days	80.36%	59.09%
Minimum level of geographical detail in trip diary (p-value Fisher's exact test: <0.0001)		
Full address	39.29%	95.45%
Street of the address	25.00%	0.00%
Municipality	26.79%	4.55%
Adm. level 1 above municipality	0.00%	0.00%
Adm. level 2+ above municipality	3.57%	0.00%
No opinion	5.36%	0.00%

With regard to role of the different aspects of the experts' profiles, Table 5.8 provides the summary results of the individual Fisher's exact tests that are carried out at an individual question level. The table provides the percentage of questions (in the questionnaire block) that are significantly depending on the profile characteristic. Overall, regional differences (i.e. differences between North-American and European experts) appear to be the most determinant. Overall, in 29.3% of the questions the continent played a significant role, peaking to 66.7% in the second block of the person questionnaire. Next to the continent, the active involvement in the NHTS survey process accounts for many of the differences.

Table 5.8: Percentage of questions that are significantly depending (Fisher's exact test) on the expert's profile

Expert's profile	ALL	HH1	HH2	HH3	PER1	PER2	PER3	TRIP
SHANTI attendance	7,6%	7,1%	20,0%	0,0%	17,6%	0,0%	0,0%	4,8%
Affiliation type	9,8%	7,1%	10,0%	13,3%	17,6%	0,0%	11,1%	4,8%
Continent	29,3%	21,4%	30,0%	26,7%	5,9%	66,7%	0,0%	57,1%
NHTS involvement	22,8%	35,7%	10,0%	6,7%	5,9%	50,0%	0,0%	47,6%
NHTS use: demand estimation	4,3%	7,1%	0,0%	6,7%	5,9%	0,0%	0,0%	4,8%
NHTS use: need estimation	6,5%	7,1%	0,0%	0,0%	11,8%	0,0%	33,3%	0,0%
NHTS use: impact assessment	10,9%	14,3%	40,0%	13,3%	5,9%	0,0%	0,0%	4,8%
NTHS use: market research	5,4%	7,1%	10,0%	6,7%	5,9%	0,0%	0,0%	4,8%
NTHS use: causal analysis	4,3%	7,1%	0,0%	6,7%	11,8%	0,0%	0,0%	0,0%

5.5 Discussion and conclusion

In this study, the essentialness of an extensive list of questions, regularly asked in NHTS, was assessed. For each of the questions a score value was determined to express the degree of essentialness. The study identifies the most pregnant questions, which should form the core of any NHTS. This list is especially fruitful for countries that do not yet have implemented a NHTS, and for defining the set of questions whenever a harmonized multi-country household travel survey will be initialised. Moreover, in an area where budgetary constraints are confining the scope of NHTS, it provides a framework for safeguarding the most essential information.

Secondly, the paper investigated whether unanimity exists in the experts' opinions. The different analysis clearly pinpointed differences concerning the experts' characteristics, thus it could be concluded that unanimity is certainly not complete. Thus, whenever developing standards for travel surveys these differences should be taken into account. Especially the differences with respect to the regional context (North-American versus European), and involvement with the NHTS should be acknowledged.

6 Proposition of a questionnaire

The goal of this section is to define a minimum set of questions in a household travel survey, so that each country can add supplementary contents as needed. The proposed exercise should be useful for those countries that are starting to run a survey, or are planning to do so in the future.

The questions are grouped in three clusters: the first one related to the household characteristics (M), the second one related to personal characteristics (P) and the third one related to trips themselves that have been made in a given reporting period, e.g. the day before, the weekend before etc. (T).

SECTION 1. QUESTIONS AT THE HOUSEHOLD LEVEL (M)

Household characteristics

H1. Type of housing to which the home belongs

1. Detached house
2. Semi-detached house
3. Small apartment building (up to three floors above the ground floor)
4. Large apartment building (over three floors)
5. Others (please state)

H2. Is the householder…

1. The owner, or in the course of purchasing the home?
2. A council house tenant?
3. Another type of tenant?
4. Housed free of charge?
5. Others (please state)

Household characteristics: Vehicle ownership

H3. Number of private cars or utility vehicles with a payload of less than 1 000 kg available to the members of the household (vehicles owned + vehicles available)- (vehicles owned + vehicles freely available to members of the household)

H4. Kind of vehicle

1. Passenger vehicle (saloon car, people carrier, estate car, commercial vehicle)
2. Camper
3. Utility vehicle payload 800 kg to 1 000 kg)
4. Small car for which no licence is required

H5a. Energy source

1. Lead-free
2. Super
3. Diesel
4. Gas
5. Electric
6. Other

H6b. Hybrid vehicle: Y/N

H7. Year of registration

H8. Taxable HP

H9. Is the vehicle?

1. Owned by the household?
2. Owned by the employer but fully available for one person?
3. Owned by the employer but partly available for one person?
4. Others (please state)

H10. At night, where is the vehicle generally parked?

1. In a private garage or other parking space
2. In the street
3. In an open-air car park (or public square)
4. In a covered car park accessible to the public

H11. At night, is this form of parking

1. Prohibited?
2. Free?
3. At least partially to be paid for by you?
4. Fully to be paid by someone else (an association, your employer, etc.)?

SECTION 2. QUESTIONS AT THE PERSONAL LEVEL (P)

P2: Gender

P3: Relation with the reference person

1. Reference person
2. Spouse
3. Child
4. Other

P4: Age / date of birth

P5: Driving license owned (for private vehicles)

1. Yes
2. No
3. Learning to drive

P6: Last educational establishment attended on a full-time basis

0. Undergoing educations
1. Primary education
2. Secondary to age 15
3. Secondary aged 15 - 18 but not having taken A-levels
4. Secondary, with A levels
5. Two-year higher education course
6. Three-year and above higher education course hip
7. Apprentices
8. No studies

P7: Main occupation

1. Full-time work
2. Part-time work
3. Apprenticeship training course
4. Student
5. At school up to A levels
6. Unemployed, seeking employment
7. Retired
8. Stays at home
9. Other

P8: Other occupation

0. Not relevant
1. Work
2. Studies

P9: What is or what was your main profession, or for schoolchildren and students, what level of education have you attained?

P10: In general, do you have a travel card for public transport?

1. Yes, it's free
2. Yes, I have to pay for it
3. No

P10: Yesterday, was this travel card valid? Yes / No

P11: For your main occupation do you work or do you study only at home? Yes / No

P12: For your main occupation, give the exact address of your place of work or study

P13: During the week (from Monday to Friday), how often do you use (give the mode) to travel?

- Bicycle
- Motorcycle
- Private car as a driver
- Private car as a passenger
- The whole of the urban network (including dedicated lanes)
- Dedicated lanes only

1. Almost every day
2. At least two journeys a week 3.At least two journeys a month
4. Exceptionally
5. Never

P14: Now we're going to talk about yesterday (yesterday from 4 am today at 4 am). Which situation best corresponds to your situation yesterday?

1. Yesterday you were present in the survey area and you travelled at least once
2. Yesterday you were present in the survey area and you didn't travel from 4.a.m. to 4 a.m. today
3. You were absent yesterday from 4.a.m. to 4 a.m. today

SECTION 3. QUESTIONS AT THE TRIP LEVEL (T)

Description of each trip

Starting point of the trip:

T2: You left from... (Reason given by the person)
T3: Located at… (Starting point fine zone)
T4: …at what time? (Starting time)

Destination of the trip

T5: …for what reason? (Reason given by the person)
T6: …at what place? (Destination fine zone)
T7: …what time did you arrive? (Time of arrival)

T8: Modes of transport

7 New technology to capture travel behaviour

7.1 Introduction

In recent years a number of new technologies, which can be used to collect data on travel behaviour, have emerged, and this has changed the datascape for travel behaviour research. This has been the focus of Working Group 2 (WG2) within SHANTI, and this chapter presents the results of this work. The work within SHANTIs WG2 has been structured around the following meetings:

- Kick-off meeting in Paris the 24-25th of September 2009
    - Focus of WG2 was defined as the following four issues in relation to new technologies:
        - State of the art of review.
        - Methods for post processing.
        - Assessment of opportunities and requirements.
        - Development of guidelines.
- London meeting the 22-24th of September 2010
    - Discussion about the purpose of using new technologies and the different technologies available. GSM and GPS emerged as the main technologies used by SHANTI researchers in relation to travel surveys.
    - A survey of SHANTI members was conducted to map the experiences with new technologies within the SHANTI network.
- Namur meeting the 2-3rd November 2010
    - The potentials and challenges of new technologies were reviewed. The meeting revealed:
        - A need clarify the definition of GPS data and a need for metadata.
        - A critical mass of experiences regarding GPS tacking had been gathered, which made it possible to create advices about how to use this technology for travel survey purpose.
        - That several other new technologies were underway, and it was impossible to conclude how these technologies might develop in the future, and thus also impossible to draw conclusions regarding their potential in a travel survey perspective.
- Vienna meeting the 13-15th April 2011
    - The potential and challenges of new technologies were reviewed, and a working group session was held, where different new technologies were

rated in relation to a number of dimensions. This work resulted in a table overview of new technologies and their potentials.
    - The meeting revealed a need to focus in more detail on reviewing the GSM technology, and therefore this became focus of the next meeting.

- Eindhoven meeting the 12-14th October 2011
    - Discussions about potentials and challenges of mobile phone tracking in networks.
- Barcelona meeting the 12-16th March 2012
    - The focus of WG2 was expanded at this meeting to the business models surrounding the use of new technologies in travel research.
- Namur meeting the 4-6th of July 2012
    - The WG2 session was cancelled at this meeting,
- Copenhagen meeting the 24-26th of October 2012
    - Focus in WG2 was expanded further, to the issue of big data, and how new technology as well as how big data might influence travel surveys in the future.

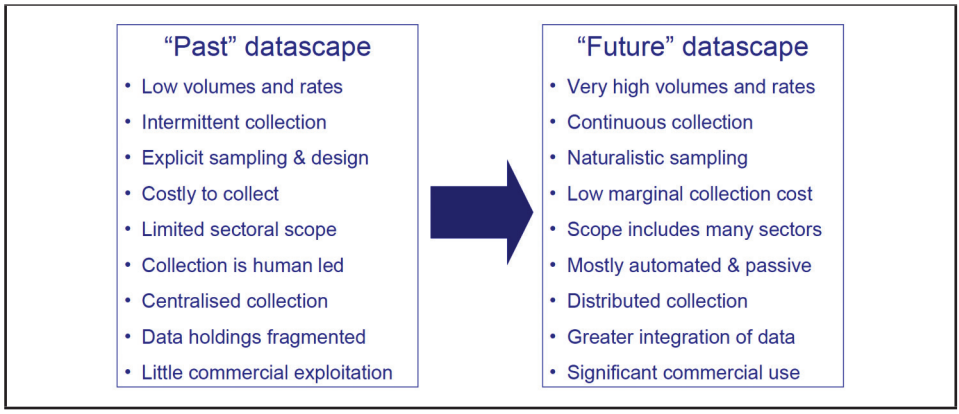
To report this work this chapter is structured as follows: Section 7.2 gives an overview of the changing datascape for travel behaviour research. Section 7.3 starts by presenting an overview of new technologies, which can be used to capture data relevant for travel behaviour research. Thereafter the section focuses in detail on GPS tracking, and thereafter section 7.3.1 discusses the lessons to be learned from GPS in relation to other new technologies. Finally section 7.4 presents some tentative reflections on the future of travel surveys and data collected using these new technologies.

7.2 The changing datascape for travel behaviour research

The WG2 discussions within the SHANTI network has made it clear, that we are facing a new situation in relation to the data basis for travel behaviour research. The emergence of new technologies for data capture has made it possible both to collect known types of travel behaviour data more efficient as well as to collect new types of travel behaviour data which presents new analytical possibilities. What has occurred is, in other words, a change in the data basis for travel behaviour research. Figure 1 describes what we call the “past” and “future” datascape for travel behaviour research.

Let us now discuss each of these 9 dimensions characterizing the change shortly, because the new datascape constitute the context for the deployment of the new technologies that we will discuss in the following sections.

Figure 7.1: Model describing the change occurring in the datascape for travel research



Characterizing this changing datascape is firstly a change in the volume and the rate of data produced. Previously data was expensive to create and therefore relatively low volumes of data were collected, and the collection was done at a low rate. Today massive amount of data is created and the pace of data creation is very high. This change is clearly shown in the discussions about Big Data, which has gained momentum in recent years (Howe et al. 2008a; Jacobs 2009; LaValle et al. 2011; World Economic Forum 2012), as well as in the discussion about volunteered geographical information (Elwood et al. 2012; Goodchild 2007).

Secondly, previously data was mainly collected in discrete steps, for example in surveys conducted at specific time intervals. Today data collection is more continual in nature, location data from mobile phones is for example stored on a continuous basis for billing purpose by network operators, and such data can play an important role in analysing the mobility of people over time, see for example (Ahas 2010; Ahas et al. 2010; Calabrese et al. 2010; Ratti et al. 2006; Sevtsuk and Ratti 2010).

Thirdly, previously data sampling and collection was mainly done according to methodological considerations, where a specific research question formed the conceptual basis for the data collection. Today data is collected in a variety of different settings for a number of different purposes, and increasingly analysis of such data relies on knowledge discovery procedures, data mining methods etc., and as such data collected for one purpose might be used for analysis in a completely different direction (Miller 2010).

Fourthly, given the advent of new technologies and due to the miniaturization process occurring both in relation to processing power and sensors, sensors are increasingly imbedded in infrastructure, vehicles and personal devices, and the costs associated with data collection has diminished.

Fifthly, and this related to the previous points, due to the naturalistic sample procedures today and the advent of Big Data, there are also increasing tendencies that data is used for several different purposes.

Sixthly, previously data collection was human led, relying for example on the distribution of surveys to respondents who had to consciously answer these, whereas today data collection is often automated and passive, for example in the case of collection of location data from smart phones, from GPS units in vehicles, sensor networks or from transaction systems. This also means that previously data collection was mainly person-to-person or machine-to-person, whereas today the collection is more person-to-machine or machine-to-machine.

Seventhly, previously data collection was mainly centralized; often one authority, organization or even researcher conducted the collection of data and analysis. Today data collection is more decentralized, different authorities, organizations or persons, collect different types of data and it is the travel behaviour researcher that combines the different types of data into one unified picture.

Eighthly, previously data was often stored in many different locations, some researchers would have some relatively small databases of collected data, organizations would have their own databases, public authorizes their own databases. Today with the advent of new tools for data management and analysis, the advent of big data, as well as the advent of organizations specializing in providing specific types of data, the data sources becomes bigger are more integrated into each other. Today companies like Google, Apple, TomTom and others are sitting on massive datasets covering large parts of the globe, for example road networks, Wi-Fi network maps etc.

Ninth, and finally, previous there was little interaction between research-based data collection and private business, whereas today a significant part of the data collection and creation in society is led by private companies. This advent of this new datascape means that we are facing new opportunities and new challenges when utilizing travel surveys as a method for data collection, and let us now turn to these.

7.3 New technologies for data capture

The discussions at the SHANTI meetings revealed that a large number of new technologies are capable of providing data that may be relevant for travel behaviour research. Some of these are:

– GNSS (Global Navigation Satellite Systems - GPS[2], GLONASS, COMPASS)
– Near field systems (e.g. RFID[3], Bluetooth[4], Zigbee)

---

[2] During the last 20 years GPS technology has started to play a significant role in the travel behavior research field, see for example (Bricka et al. 2012; Chen et al. 2010; Feng et al. 2011; Gong et al. 2012; Houston et al. 2011; Oliveira et al. 2011; Schuessler et al. 2012; Stopher and Speisser 2011; Xu 2010). GPS is however only one of several technologies under the umbrella Global Navigation Satellite Systems (GNSS). The Russian GLONASS system is also operational today and used in several smart phones (www.glonass-ianc.rsa.ru 2012) and a number of other systems are underway, for example the European Galileo system (www.esa.int 2012) and the Chinese BeiDou system (www.beidou.gov.cn 2012).

[3] RFID tags has been used in several studies in recent years especially in indoor settings (Chumkamon et al. 2008; Saeed et al. 2010; Sardroud et al. 2010; Zhang et al. 2011a)

[4] Bluetooth is for example used for traffic estimation, see for example (Araghi et al.; Lahrmann et al. 2010). Smart card systems, see for example (Bagchi and White 2004; Bagchi and White 2005; Chapleau et al. 2008; Morency et al. 2007; Pelletier et al. 2011)

– Communications (Cellular telephony GSM[5], 3G, 4G, Wifi, WiMax (802.x))
– Transaction systems (e.g. smart cards)
– Embedded sensors (on people, vehicles, infrastructure)
– Sensor networks and cooperative technologies
– User contributed content (e.g. social networking data)
– Camera networks (e.g. CCTV)
– Social networks (e.g. Facebook, Twitter, Flickr)

To make sense of these technologies and their potentials, it is necessary to be clear about firstly the characteristics of the technologies, i.e. how they functions, what kind of data they can provide etc., and secondly the methodological setup in which they are deployed.

At the Vienna meeting in 2011 a list of new technologies and their characteristics were compiled by the meeting attendants, and an updated version of this list is shown in table 7.1, where the technologies have been classified into groups using colours to give a better overview.

The first technologies in table 7.1 are GNSS (green) and active and passive mobile phone positioning (orange). These are the currently most used tracking technologies, and it is therefore necessary to be clear about the differences:

- GNSS positioning: The most widely used GNSS system is the GPS, and to understand the functioning of this system we may distinguish between pure GPS and assisted GPS (A-GPS). It should be noted, that other operational GNSS include GLONASS and COMPAS which functions in almost the same way as GPS.
    - Pure GPS positioning: A radio signal containing satellite-time, satellite-status, satellite-health, satellite-position and the position of all other GPS satellites are transmitted from the GPS satellites. These signals are then received by a GPS receiver, which calculates the distance to each satellite (in sight) using the delay in the time-signal. Using these distances and the data on the position of the satellites, it is thereafter possible to triangulate the position of the receiver (van Diggelen 2009).
    - Assisted GPS positioning: Some GPS receivers receive data on the position of all GPS satellites via a WIFI or mobile data connections. This has two advantages. Firstly, due to the way in which the information sent from the satellite is modulated on top of the carrier frequency, this speeds up the position calculation significantly. Secondly, the GPS signal is modulated in a way which means that it may be possible, under certain conditions, for example inside buildings or vehicles where the signal is weak, to derive the time and satellite id from the signal, but not the comparably long and complex data about satellite position. Therefore if this is available from ano-

[5] *This technology has for example been used in the literature to model places meaningful to respondents (Ahas 2010; Ahas, Slim, Järv, Saluveer, & Tiru 2010), to study mobility of people within cities (Calabrese, Colonna, Lovisolo, Parata, & Ratti 2010; Ratti, Williams, Frenchman, & Pulselli 2006) and to study the daily rhythm of cities (Sevtsuk & Ratti 2010).*

ther source, then it is still possible to calculate a position, and A-GPS thus enhances the positioning possibilities of the receiver (van Diggelen 2009).

- GSM Positioning: The position of a GSM handset can be obtained in two ways, actively and passively.
  - Passive positioning: The positioning of the handset is derived from log-files created by mobile network operators. Network operators create log files of all activities of the handsets in the network, i.e. of calls, text-messaging and data transfer activities, and these logs include data about what antennas the handsets were connected to when the activities occurred. From the network operators perspective these log files are created for billing purpose, but from a travel behaviour research perspective, these log files can be used to derive where the phones were geographically at different times when combined with a map over the GPS antennas in the network (Ahas 2012). This kind of positioning is sometimes referred to as on-call tracking because it is the handset, i.e. user or applications running at the handset that initiates activities, which can be traced in the network.
  - Active positioning: A network operator can make a probe inquiry in the network to establish the location of a specific handset, i.e. ping the handset, so that the handset replies the network, and thus reveals what antenna it is connected to, and thus what area it is located in. How this is done technically varies (Ahas 2012). This kind of positioning is sometimes referred to as off-call tracking because the network, which turns the phone active and thus traceable, initiates the positioning.

Table 7.1: The characteristics of a number of new technologies, table is compiled by participants at the SHANTI meeting in Vienna in 2011

Positioning technology	Information	Extra data	Data quality	Data accuracy	Data continuity
GNSS (GPS, A-GPS, GLONASS, COMPAS)	Long, lat, timestamp, speed, directions, hdop, vdop	Personal data is possible by questionnaire	Good	High (meters)	Good
Active mobile phone positioning (Off-call tracking)	Long, lat, timestamp, accuracy measurement	Personal data is possible to questionnaire	Depends on the mobile network. Average	Accuracy depends on an area (meters - hundreds of meters)	Good
Passive mobile phone positioning (On-call tracking)	Cell, timestamp, (age, sex, language used...)	No (privacy laws)	Sample size is huge, but on individual level the quality is poor	Accuracy depends on an area (m - km)	Average

Table 7.1: The characteristics of a number of new technologies, table is compiled by participants at the SHANTI meeting in Vienna in 2011 (suite)

Positioning technology	Information	Extra data	Data quality	Data accuracy	Data continuity
Terminal based positioning (program installed on the phone)	Long, lat, timestamp, speed, directions, hdop, vdop, accelometer data, magnetic fields, status of the battery, personal information if you get acceptance from the user (e.g. facebook networks)	User input and data fusion possible	Good	Accuracy depends on an area (meters - hundreds of meters)	Good
Bluetooth tracking	Location, timestamp	No (privacy laws)	Poor (requires network of sensors and sample is biased)	Good	Poor
RFiD	Location, timestamp	No (privacy laws)	Poor (requires network of sensors)	Excellent - accuracy can be the best of known technologies (in cm)	Poor
RDS	Location	No	Poor	Accuracy not so good (~1 km)	Good
Video tracking (number plates)	Location, timestamp, number plate	No (privacy laws)	Poor (requires network of cameras and there are many recognition errors)	Good (right in front of camera)	Poor

Table 7.1: The characteristics of a number of new technologies, table is compiled by participants at the SHANTI meeting in Vienna in 2011 (suite)

Positioning technology	Information	Extra data	Data quality	Data accuracy	Data continuity
Registers (credit card info etc.)	Location, timestamp, user identification	In some countries you can combine different registers	Sample size is huge, but on individual level the continuity and data quality is poor	Good (an address level)	Poor
Smart Cards	Location, timestamp, user identification	No (privacy laws)	Average	Good (if you have geocoded reader locations)	Average (depends on the size of the network and how much it's used)
Toll systems (anonymous)	Location, timestamp, car identification	No (privacy laws)	Poor (requires network of cameras and there are many recognition errors)	Good (right in front of camera)	Poor

Given these differences between the GPS tracking and mobile phone tracking, it is necessary to be clear about whether a given research projects utilizes one or the other technology. A GPS tracking project might rely on stand-alone GPS devices or on GPS receivers embedded in mobile phones. Likewise a tracking project might utilize mobile phones and do mobile phone tracking, either active or passive, where it is data from the network operator on the location of antennas and mobile phone activity which is the basis for the positioning and not the GPS receivers in the phone.

Positioning using a combination of data from different receivers on mobile phones is also possible, for example combinations of data from GPS receivers, accelerometers, Wi-Fi-radios, gyros and compasses, as we will elaborate on later, and this is shown as brown in Table 7.2. Earth-based position technologies which rely on radio waves are shown in purple, visual technologies in blue and systems where it is the position of terminals used by respondents which form the basis for the positioning is shown in yellow.

Table 7.2constitutes a starting point for decisions about what technology to choose for a given travel behaviour research project. GPS technology may for example be a good choice if the project objectives demand a high level of precision in the tracking data (e.g. bill-board watching for measuring the impact of advertising), whereas passive mobile positioning tracking might be a better choice if a large sample size is more important than geographical precision in the collected data.

One thing is, as underscored earlier the characteristic of the technology. Another is the methodological setup in which the technology is deployed. The discussions within WG2 and a review conducted of literature on new technologies revealed that GPS tracking is the technology with which there is sufficient experience for it to be a “role-model” in relation to how new technologies should be approach within the travel behaviour community methodologically. Therefore the following section will focus in detail on GPS tracking and the lessons to be learned from this technology in relation to travel behaviour research. Thereafter section 7.3.1 will focus on other new technologies, and how the lesions learned from GPS can enhance the use of these, and as such section 7.3.1 will return to Table 7.2.

Tracking can be combined, and thereafter section 3.1.2 focuses on the methodological issues which emerge when the technology is deployed, and how these may be addressed given previous experience.

7.3.1 GPS tracking and Travel Diaries

Trips, mode and purpose form the link between GPS tracking and Travel Diaries. Basically, the reason for combining the two is that GPS tracks have the advantage compared to travel surveys, that they provide detailed geographical information about all trips, detailed information about the timing of all trips, there is in principle no problem with underreporting, and the burden placed on the respondents is smaller (Schuessler and Axhausen 2009a; Wolf et al. 2001). In other words, if we apply GPS tracking to capture trips, mode and purpose data for travel behaviour research, then we might do that better and more efficiently than if we do it by traditional travel diaries.

A literature has therefore emerged on trip, mode and purpose identification in GPS data. Characterizing this literature is that early publications dealt with trip and mode recognition alone, whereas newer contributions presents more elaborate methods, which can derive trips, mode and purpose. Currently there is no consensus about the best method for this, so therefore we will present the main contributions categorized according to whether they deal with trip and mode recognition alone, purpose derived from GPS data alone, purpose derived from GPS data in combination with other GIS data sources, and finally GPS data in combination with GIS data and input from the respondents, the last mentioned being close to the so-called prompted-recall studies which are currently argued to be the optimal way to utilize GPS tracking in relation to travel surveys, which will be discussed by the end of this section.

7.3.2 Trip and mode recognition

The seminal contribution in the line of literature dealing with trip identification in pure GPS data is (Schuessler and Axhausen 2009b), who developed a method for identifying trip distance, duration and mode based on GPS data alone based on stages and speed in the pure GPS data. Newer contribution dealing with trip and mode recognition have suggested a combination of GPS data and GIS data, for example (Chung and Shalaby 2005), who developed a similar method for identifying modes of transport building on three steps. The first was to process the GPS data to a GIS data format, the second was to map match the GPS data to road network, and finally the third step was to use a number of rules to derive the transport mode used for the travel on the basis on information in the road network (Chung & Shalaby 2005). Another approach, which is becoming widespread, is to combine GPS data with data from accelerometers to gain a better identification of trips and mode, see for example (Parlak et al. 2012).

7.3.3 Purpose from GPS data alone

(Zhou et al. 2007) presented a method to derive places of interest from GPS data alone and suggest a two-step solution in which the first step is to analyses patterns in the GPS data using cluster analysis methods to identify places of interest, and the second step is to infer the type of interest from the number of visits to these locations, the timing of the visits and the lengths of the visits. Using this approach (Zhou, Bhatnagar, Shekhar, & Terveen 2007) is able to derive four categories of places “Important and frequent places” (home, work etc,), “Important and infrequent places” (parents’ house etc.), “unimportant and frequent places” (gas station etc.) and “unimportant and infrequent places” (restaurants etc.) (Zhou, Bhatnagar, Shekhar, & Terveen 2007, no page numbers). As can be seen these categories are relatively broad, and a way to obtain a more precise purpose is through the combination of GPS data and complementary GIS data on for example land use.

7.3.4 Purpose from GPS data combined with complementary GIS data

The seminal contribution in the literature about deriving trip mode and purpose from a combination of GPS and GIS data is by (Wolf, Guensler, & Bachman 2001), who developed a method for calculation of trip purpose in which the first step was to identify start and stop points in the GPS data, then to identify the land use and addresses of these points using complementary GIS data, then from these derive the trip purpose and then finally calculate the length of trip etc.

(Wolf, Guensler, & Bachman 2001) showed that although such automatic assignment of trip purposes has potential, identification of trip purpose is impossible in certain land-use-types, especially in mixed-use areas such as shopping

centres; stops here could be for example eating, shopping or business, and it is not possible to distinguish between these purposes just from the timing of the visit (Wolf, Guensler, & Bachman 2001). Further, the land-use and address data might not be complete in all areas, which again makes purpose estimation impossible. (Wolf, Guensler, & Bachman 2001)'s conclusion was thus, that the method could be used to identify purpose for roughly 78% of the trips; the rest would have to be collected through CATI retrieval calls.

Another contribution using a similar method is (Chen, Gong, Lawson, & Bialostozky 2010) who also used four components, a GPS tracking survey, a multi-modal network database containing information about the environment and facilities, an identification of trip mode and an identification of trip purpose, and with their model they could derive purpose for 67% of home-based trips and 78% for non-home-based trips in their case area. For other publications related to trips, mode and purpose derived from GPS data, see also (Arifin and Axhausen 2011; Ashbrook and Starner 2002; Ashbrook and Starner 2003; Bamis and Savvides 2010; Bhawalkar et al. 2004; Schuessler, Balmer, & Axhausen 2012; Stenneth et al. 2011; Zhang et al. 2011b).

7.3.5 Purpose from GPS data combined and input from respondents

(Stopher et al. 2008) develop a method for identification of trip purpose where respondents were asked the address of their workplace as well as the address of their two most frequently used supermarkets or grocery stores. Thereafter the home address, work/school addresses and shopping addresses were geocoded, and these form the basis for identification of trip purpose in the GPS data. These addresses alone make it possible, according to (Stopher, Clifford, Zhang, & FitzGerald 2008), to identify 70 percent of the trip purposes. For the trips where it was not possible to identify trips using these address points, information from a GIS land-use database was used as a supplement to calculate trip purpose. (Bohte and Maat 2009) also developed a method for calculating trip purpose, by combining the GPS tracks with detailed GIS data describing the facilities at different location in the study area, and by doing so they were capable of defining 13 different trip purposes. By asking input from the respondents (Stopher, Clifford, Zhang, & FitzGerald 2008) methodologically moved towards the so-called prompted recall studies.

7.3.6 Prompted recall studies

There is, as the different approaches presented above implies, currently no method which is capable of deriving trip mode and purpose for all trips, partly due to the difficulties of doing so in mixed-land-use areas. Therefore the current argument in the literature is, that the best method for collecting travel behaviour data is a combination of GPS tracking and diaries (Bricka, Sen, Paleti, & Bhat 2012).

This combination is the basis for the so-called prompted recall studies (Auld et al. 2008; Wolf 2006), also known as interactive studies (Chen, Gong, Lawson, & Bialostozky 2010), where trips obtained from GPS data is used to minimize the number of questions given to the respondent in the diary. This lowers the burden placed on the respondents which means the survey period can be extended to weeks or even longer and further the method is capable of capturing types of trips, which are often missed in traditional travel diaries (Bohte & Maat 2009; Frignani et al. 2010). The largest weaknesses of this method have according to the literature been privacy issues and technical challenges, which are common to GPS studies (Chen, Gong, Lawson, & Bialostozky 2010).

Summing up we thus see, that currently a number of different methods for deriving trips, mode and purpose from GPS tracks have been presented in the literature, but there is no consensus about which is best, no method is capable of identifying mode and purpose for all trips, and the suggested combination of GPS tracking and travel diaries is therefore prompted-recall studies. This raises the question that if a GPS tracking data collection is to be conducted, how should it then be designed methodologically? Since there is no consensus in the literature about how to design, conduct and analyse results from a GPS tracking surveys, the recommendations in this report can only be to summarize upon the experiences with GPS tracking in the literature and sketch some issues which researchers has to reflect upon if they decide to use GPS tracking in combination with travel surveys, and this will now be the focus of next section.

7.3.7 Designing and conducting a GPS tracking data collection

To understand the issues one are facing when designing and conducting a GPS tracking data collection, it is useful to think about the three dimensions the technology, the data collection methodology and what kinds of analysis that are to be done on the collected data. Be reviewing the GPS tracking literature and drawing on our own experiences with GPS tracking projects, we have identified a number of issues in relation to each of these three dimensions, which are crucial when designing and conducting a GPS tracking data collection. These are shown in Table 7.2.

The issues shown in Table 7.2 are all interrelated, the choice of dedicated device vs. smart-phone app for example depends upon the sample group as well as the objective of the study, which in turn also have a close relation to the analysis which are to be done and so forth. Since there are no best practice in the field about how to design a GPS tracking data collection, and since the choices made in relation to these issues in Table 7.2 must depend upon the objective of the research project at hand, the following discussion of these issues are structured so that each issue is discussed in detail, where after the discussions are summarized in a table, Table 7.3, according to what state-of-the-art in relation to the given issues are, and what researchers need to reflect upon in relation to the given issues.

Table 7.2: Dimensions and issues which previous experiences with GPS tracking shows are important to reflect upon when designing and conducting a GPS tracking data collection

Dimension	Issue
Technology	Dedicated device? Smart-phone app? Auxiliary technology? Logging frequency? Battery life? Precision/quality?
Data collection methodology	Sample group, size and length of tracking period? Passive vs. active tracking? Motivation of respondents? Business model?
Analysis	Trip? Mode? Purpose?

This section thereby summarizes the past experiences with GPS tracking into a list of issues, which a researcher needs to reflect upon when designing and conducting a GPS tracking investigation, and as such a list, which can support the future, use of this technology in relation to travel behaviour research. Let us start with the issues arising in relation to the technology used as specified in Table 7.2.

7.3.8 Technology

7.3.8.1 Dedicated GPS device

Several studies have relied on dedicated GPS devices for data collection, and there are two main groups of devices: Devices that transmit collected GPS data continually to servers using a GSM radio, and devises that do not do so. Studies utilizing the first type include (Harder et al. 2012c; Reinau et al. 2012), studies utilizing the last type include (Schuessler & Axhausen 2009b). Both types of devices have strengths and weaknesses. Whereas the size of GPS devices without GSM radio may be smaller and the battery life longer compared to GPS devices with GSM radio, the advantage of GPS devices with GSM radios is that researchers can monitor the data collection in real time. This makes it possible to evaluate whether respondents are remembering to carry their devices as well as to contact them in case of errors on the devises. On the other hand, this real-time monitoring of activity might also constitute a challenge for the respondents in terms of privacy and may prevent some from participating. If a dedicated device is to be used in a data collection, it is therefore important to reflect upon the issues of size and portability, battery life, the possibility of real-time monitoring of respondents, error detection and privacy.

7.3.8.2 Smart-phone Apps

A growing number of studies are utilizing smart-phones for GPS tracking purpose, for example (Alzua et al.; Barbeau et al. 2008; Froehlich et al. 2007; Knudsen et al. 2011a; Narin et al. 2009; Stenneth, Wolfson, Yu, & Xu 2011). Advantages of this relates firstly to the issue of remembering the GPS tracker. While respondents sometimes forget dedicated GPS devices it seems plausible that they more rarely forget their mobile phone. Likewise it is also plausible that respondents more often remember to charge their phone than a dedicated GPS device with which they are unfamiliar. However, whether they remember to use the application on the phone is unclear. Secondly, the use of smart-phones opens the possibility of making experience sampling method inspired setups where the respondent is prompted with questions during the tracking investigation, see for example (Fischer 2009) for more information on the use of smart phones in experience sampling studies. Thirdly, the penetration of smart phone usage in a given population is also crucial to the successful utilization of this approach. The penetration of smart phones by 2011 was 90% of the population in Singapore, 52% in Sweden, 45% in Denmark, 40% in Great Britain, 35% in USA and 30% in France to give some examples (www.wired.com 2012). With the price development in the smart phones market it is also becoming an option to supply smart phones to respondents instead of dedicated GPS devices, a solution which was for example used in (Knudsen, Harder, Simonsen, & Stigsen 2011a; Knudsen et al. 2011b). Fourthly, with the other sensors typically embedded in smart phones, such as accelerometers, compasses and gyros, the use of smart phones apps also makes it relatively easy to collect auxiliary data from these other sensors which can be used in the further analysis of the GPS data for example trip and mode detection.

7.3.8.3 Auxiliary technology

Some studies use pure GPS data, i.e. only position and time data, for example (Schuessler & Axhausen 2009b). However, if the GPS data is combined with data from other types of sensors the potential for deriving valuable information from the data is enhanced. A widely used auxiliary technology is accelerometers, which have been used in relation to deriving trip mode from GPS data (Parlak, Jariyasunant, & Sengupta 2012), in the literature on context-aware computer systems where data from accelerometers is often combined with GPS data (Bristow et al. 2002; Intille et al. 2003; Intille et al. 2004), to derive data on physical activity (Abraham et al. 2012; Christensen et al. 2011; Cooper et al. 2010; Cooper and Page 2010; Doherty and Oh 2012) and in GPS tracking studies in general to enhance the battery life of the GPS device by only tracking positions when the device is moving according to the accelerometer and thus only tracking when the device is moving (Benisch et al. 2008; Benisch et al. 2011). Other technologies include: Compasses and Gyros. Pedometers, which can be used to derive data on physical activity (Christensen, Mikkelsen, Nielsen, & Harder 2011). Temperature sensors may have potential also as well light Sensors (Bradley and Dunlop 2008). A range of specialized sensor has also been combined with GPS tracking in physiology and health studies, for example electrocardiogram and blood glucose monitors (Doherty & Oh 2012). Skin conductivity

monitors have also been used in GPS tracking studies exploring how people feel while moving through the city (Nold 2009). Wi-fi technology can be used to enhance the position precision in for example smart phones, and finally, several smart phones also have GLONASS receivers. GLONASS is not auxiliary to GPS since it is another GNSS technology, but phones which utilize both technologies holds potential for deriving tracks with higher precision than if the positioning relies on GPS alone.

7.3.8.4 Logging frequency

The logging frequency of GPS devices used in the literature on GPS tracking varies from very high, for example one position every second, to very low, i.e. several minutes or hours between each position (Wang et al. 2011). In studies utilizing personal GPS devices a range of different frequencies has been used, (Harder et al. 2011b) for example used 10 seconds while (Auld et al. 2009a) used 15 seconds. The choice of logging frequency depends upon a number of issues: the technology available, i.e. what frequencies can be obtained with the used GPS device. The objective of the study, if for example map matching is to be done on the collected data, demands for logging frequency is to a certain extend dictated by the map matching algorithms. In other words, a relatively high frequency normally has to be achieved to make map matching possible, whereas a low logging frequency might be acceptable if the objective only is to achieve knowledge about the general whereabouts of the respondent. Finally, for some GPS devices the logging frequency choices also have impact upon power consumption, with a high frequency leading to low battery lifetimes. Therefore, it is also necessary to reflect on how often the respondent needs to recharge the GPS device, and if it for example is better to have a longer battery life than a short battery life and high logging frequency.

7.3.8.5 Battery Life

Our experience from planning and executing tracking projects utilizing GPS devices and smart phones which formed the basis for publications such as (Christensen, Mikkelsen, Nielsen, & Harder 2011; Glud et al. 2009; Harder et al. 2011a; Harder et al. 2012a; Harder et al. 2012b; Harder, van Nes, Jensen, Reinau, & Weber 2012c; Jensen et al. 2011a; Jensen et al. 2011b; Reinau, Harder, & Jensen 2012), is that when conducting a GPS tracking project the battery life of the GPS device used plays a key role. If the objective for example is to track everyday mobility using a personal GPS device and the battery of the device used only is 4 hours, then it means either that the GPS device will stop working during the day, which will lead to data loss and incomplete tracks, or that the respondent has to charge the device during the day, which in turn leads to an altered respondent behaviour, which in turn influences the conclusions which can be drawn from the data collected. As mentioned earlier, choice of battery life is often a trade-off, for example in relation to logging frequency, and also in relation to the use of auxiliary sensors, for example accelerometers, since an increase in sensors may also increase the power consumption. Further, when designing specialized smart phone apps for data collection the power consumption is also a key issue see for example (Froehlich, Chen, Consolvo, Harrison, & Landay 2007).

7.3.8.6 Precision/Quality

The quality of GPS tracks can be evaluated along several dimensions; firstly along the geographical precision in meters, secondly in relation to the completeness of the collected tracks, and thirdly in relation to how many trips of the total amount of trips conducted by the respondent during tracking project that was tracked. Let us look at these in turn. Regarding the first quality measure, the geographical precision of each waypoint collected depends upon the GPS device used, i.e. the quality of the antennas, the algorithms, whether differential GPS was used etc.; on the constellation of satellites and atmospheric conditions at the moment of position; and finally on the physical surroundings of the device: Was the device indoor or outdoor, in a metro, bus, car or train which might to different levels obstruct GPS signals? Was the device located in an urban street canyon with buildings obstructing GPS signals or in open countryside with clear view of the sky? How was the GPS device worn by the respondent, was it in a key hanger or a belt holder, or in a pocket in a thin jacket high on the respondent leading to relatively good reception of GPS signals or were it hidden in the bottom of a bag under other things leading to relatively bad reception of GPS signals? And were there any radio transmitters nearby jamming the GPS signal? Our experience from previous GPS tracking investigations have been that it is important to explain to respondents how to carry dedicated GPS devices to enhance the quality of the GPS signals. Secondly, when GPS data is collected the first step is the cleaning of data, as mentioned earlier, which leads to holes in the collected data, which in turn raises the issue of how large holes in the tracks that should be allowed before the tracks are discharged in further analysis. According to (Schuessler and Axhausen 2008) the threshold value used for gaps vary between 45 and 300 seconds normally in the literature. Finally, when looking at how many complete trips that was collected for a given tracking survey respondent, it is also necessary to focus on how many trips that should have been collected, and there is a literature which compares results of GPS tracking to results of travel diaries. (Forrest and Pearson 2005) for example compared GPS tracks from vehicles to travel data collected using a CATI travel survey, and found that the number of trips identified in the GPS data was much greater than the number of trips identified in the travel data. However, it is still difficult to estimate exactly how many trips out of the total amount of trips conducted by a respondent a GPS device captures: does the fact that a respondent do not have any trips in his/her GPS data for a whole day for example mean that there were an error in the GPS device or is it a result of the respondent staying indoor for a whole day?

Let us now turn to the data collection methodology and the issues arising in relation to this according to table 2.

7.3.9 Data collection methodology

7.3.9.1 Sample group, size and tracking period

The respondent sample used in the GPS tracking literature varies along different dimensions: the socio-economic characteristics of the target group, the size of

the sample tracked and the length of the tracking period. Firstly, a range of studies has focused on GPS tracking of households; see for example (Auld et al. 2009b; Bricka et al. 2009; Oliveira, Vovsha, Wolf, Birotker, Givon, & Paasche 2011; Ong 2009; Stopher et al. 2010; Stopher & Speisser 2011; Stopher and Wargelin 2010). A number of studies have also focused on more specific age groups, for example children (Badland et al. 2011; Christensen, Mikkelsen, Nielsen, & Harder 2011; Cooper, Page, Wheeler, Hillsdon, Griew, & Jago 2010; Elgethun et al. 2003; Elgethun et al. 2006; Fenske et al. 2005; Gong and Mackett 2008; LeMaster et al. 2011; Mavoa et al. 2011; Quigg et al. 2010), youngsters (Harder et al. 2010; Harder, Bro, & Knudsen 2012a; Harder, van Nes, Jensen, Reinau, & Weber 2012c) and older people (Auslander et al. 2010; Landau et al. 2009; SHOVAL et al. 2011). The socio-economic characteristic of the target group is important in relation to designing the tracking project, both in relation to questions about how to recruit the respondents and keep them motivated for participation, as well as in relation to technical issues such as choosing a GPS device or designing a smart phone application for the given target group. Secondly, the size of the sample varies, in some studies only a few persons are tracked, (Neuhaus 2009) for example tracked 20 respondents for two months, many studies uses a few hundred respondents and some even thousands of respondents. Thirdly, the length of the tracking period also varies, from only a few hours in some cases to several months in other cases. The choice of sample group, sample size and tracking period must depend upon the objectives of the tracking study. If the objective is to evaluate route choice a large sample and a short tracking period might be preferable whereas a smaller sample and longer sample period might be preferable if a pattern analysis is the objective of the study.

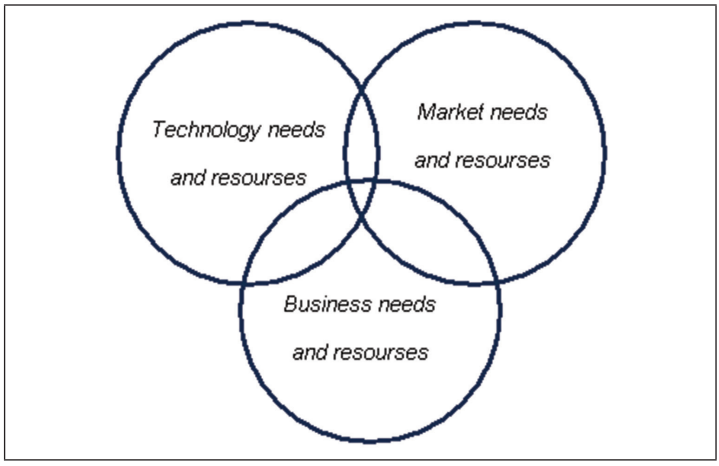
7.3.9.2 Passive vs. Active tracking

In passive studies respondents only have to carry the GPS unit, which minimizes the burden placed on the respondent, but also entails that trips, modes and purposes have to be derived from the GPS data alone. IN active studies on the other hand, respondents have to answer questions before and/or during and/or after the tracking (Chen, Gong, Lawson, & Bialostozky 2010). Studies of the first type include (Chung & Shalaby 2005), studies of the last type include (Auld, Williams, Mohammadian, & Nelson 2009a; Reinau, Harder, & Jensen 2012). Studies of the latter type often bares resemblance to prompted recall studies or experience sampling method based studies, see for example (Auld, Williams, & Mohammadian 2008; Auld, Williams, Mohammadian, & Nelson 2009b; Greaves et al. 2010; Oliveira, Vovsha, Wolf, Birotker, Givon, & Paasche 2011; Stopher, Prasad, & Zhang 2010) on prompted recall studies and GPS tracking and (Fischer 2009) on the technological side of experience sampling studies. Further, if an active design is used, it worthwhile to use the advice from the experience sampling method literature, that if questions is posed to respondents during their everyday lives, using for example smart phone apps, then it is necessary to keep the amount of questions to a minimum and keep them easy to answer, to maintain the motivation and participation of the respondents (Barrett and Barrett 2001; Fischer 2009; Scollon et al. 2009).

7.3.9.3 Motivation of respondents

An important side of a GPS tracking project, which is rarely discussed in articles dealing with GPS data, is the issue of how the respondents are recruited and motivated to carry a GPS device, and in the case of active studies, answer questions, surveys etc. With motivation of the respondents we do not mean the theoretical and methodological discussions sounding the sample group, and how the respondents are chosen, but instead how the given respondents are motivated to participate on a personal level. As the discussion above has showed, conduction a GPS tracking project entails a range of technological questions such as: what type of GPS unit should be used? How accurate should the GPS unit be? With what time interval should it log positions? What should the battery life be? Should other types of data to complement the GPS data be collected, and if so what data and how? This focus is indeed important, but we will make the argument, that such a technological focus can only be part of the full picture. It is also necessary to look at the "market" in which our technology is to be used and the "business system" we produce to make sure that this market "buys" our technology. To make this argument we will draw on the ideas on design of ventures and innovation developed by Andrew Hargadon (2003; 2005). Hargadons (2005) argument is that successful innovation, and thus successful ventures, depends on three spheres coming successfully together; the technology needs and resources, the market needs and resources and the business needs and resources. This is illustrated on figure 2.

Figure 7.2: Hargadons (2005) model illustrating the three spheres important for successful ventures



In GPS tracking project we can conceptualise the GPS tracking technology and auxiliary technologies as well as travel surveys as the technology sphere in Hargadons (2005) model. The respondents constitute the market, i.e. the goal is to sell the idea of participation in the research project to the respondents so that they participate and do so in a motivated way. Finally, the business

sphere in Hargadons (2005) model should be conceptualised as the system which is created around the GPS tracking investigation, i.e. how the recruitment of respondents and the communication flows with these are organized, how the distribution and collection of GPS tracking equipment is organized, how the technical backbone of the GPS tracking equipment is organized, i.e. our servers which collect the data, how funding for the tracking project is obtained and used etc. This whole system has to be designed in a way that aims at securing that we reach the respondents and that they are motivated for participating in the research project.

Focusing on this market sphere of the investigation, we have to reflect on how we as researchers interact with the humans we are studying through our research, how we impact their life, and how we secure their cooperation and their motivation. To put it short, we may provide a respondent with what may be technologically the most precise GPS unit in the world, but that does not result in any usable tracks, if the respondent is not motivated for participating in the survey, and therefore forgets the GPS unit at home every morning. This is a failure of the business system. Or if he or she does not know how to use the GPS unit, in which case we are facing a failure of the technology. To make a metaphor drawing on the wireless telecommunication industry, history showed that the WAP service of the early 2000's never became any success because it was too complicated for ordinary people to use it. For the telecom engineers who developed the WAP service, it was a fantastic tool, but ordinary people did not understand how to use it and therefore they did not use it (Steinbock 2005). To put it differently, when conducting GPS tracking research, we use a method where we as researchers interact with the people we are studying, and although it may not be as direct as it is the case in for example an qualitative interview situation, we nevertheless form a relationship with the respondents where we have to create trust etc. The story of Apple in recent years, as well as many other stories from the technological industries has shown that success in the technological sphere depends both on the hardware, the user experience and the business system. And this leads us to our final point to business system, as specified in table 2.

7.3.9.4 Business System

We argued in the beginning of this chapter that the datascape is changing, and this entails a number of new challenges and possibilities. One of the changes is as mentioned, that there is significant commercial exploitation of travel behaviour data today collected by different technologies. We therefore need to start thinking about both the business systems we create around our research as well as the business models behind our research. Let us again look at the high-tech industries for inspiration, and focus on Apple. Hargadon (2005) thus argues, that what set the iPod apart from other Mp3 players were the business system, and how the iPod was nested into a complex network of iTunes, Mac computers etc., which gave the costumers an experience which they valued. And this touches on something important, which Pine and Gilmore (1999) more than any has highlighted in their notion of the experience economy; to be

successful a venture has to provide its customers with a valuable experience, or to frame it in relation to our research field, we have to design our venture so that the respondents are provided with a valuable experience of participation, because this is the key to collecting GPS data of high quality. This means that in our research project we have the technology, i.e. the GPS technology, we have to grow the market, i.e. create motivated respondents, and we also have to create a business system, which makes it possible for the customers, i.e. the respondents, to use the technology in a way which gives them a valuable experience. The respondents have to see the participation in the research project as something rewarding, for example by feeling that they contribute to an important piece of research, or else they will not participate.

To round of the discussion, let us now focus on the analysis of GPS tracking data, and since we are seeing this in relation to travel surveys, we will focus on the following three issues: Trips, Mode and Purpose.

7.3.10 Analysis

7.3.10.1 Trips

A number of different methods for identification of trips have been identified in the literature on GPS tracking. Currently there is no best practice in the field, and the identification of trips depends firstly on the logging frequency, i.e. the higher the frequency, the easier it is to identify starts and stops and thus trips in the data. Secondly, the trip identification also depends upon the availability of data from auxiliary technologies, for example data from accelerometers. One recurring discussion is also how long time a stop in a track should last before it qualifies as the end point of one trip and beginning of a new, see for example (Schuessler & Axhausen 2008). Another issue is how short a trip can be to quality as a trip, and whether the threshold value should be a physical length, i.e. minimum 100 meter, or a time length, i.e. minimum 5 minutes in duration, or both.

7.3.10.2 Mode

Different mode identification procedures have been identified in the literature, as discussed above. These range from procedures relying on pure GPS data, for example (Schuessler & Axhausen 2009b) over studies which utilize GPS data in combination with data from accelerometers, for example (TROPED et al. 2008), to contributions which also include other types of geodata in the analysis as well as statistics on the likeliness of changes between different mode-types, i.e. chances of changes from bus to car, from bike to walking etc., for example (Zheng et al. 2008). The possibilities of mode calculation depends upon the logging frequency, i.e. the ability to identify movement speeds and changes in such, on the availability of data from auxiliary technologies, and finally on the availability of others sources of spatial data and statistical data, for example spatial data on public transport networks and statistical information on the probabilities of different types of mode changes.

7.3.10.3 Purpose

As discussed above a number of different methods have been presented in the literature for deriving purpose of trips in GPS data. As with mode identification, the procedure for purpose identification depends on the auxiliary data available, as illustrated in the presentation earlier of different approaches used in the literature. Some studies relies on GPS data in combination with GIS data on transport networks, land use information, addresses and even specific information about home and work places as well as most often used shopping venues. We can now summarize the discussion above in the Table 7.3 below, which can be used as a starting point when planning to do a GPS tracking investigation.

Table 7.3: The table shows a number of key issues to reflect upon when planning a GPS tracking project

Issue	State of the art	Things to reflect upon
Technology		
Dedicated GPS device	Several studies have utilized dedicated GPS devices, and there are two main groups of devices: Devices, which contain a GSM radio and transmits collected GPS data continually, and devises that do not do so.	Size and portability, battery life, possibility of real-time monitoring of respondents, error detection and privacy.
Smart-phone Apps	A growing number of studies utilize smart phone apps, which use the GPS sensor as well as other sensors in the phones for data capture.	Remembering the phone, the app and to charge the phone. Experience sampling method inspired set-ups. Penetration of smart-phones in target population, and potential distribution of smart phones to respondents. Collection of data from other sensors in the smart phone.
Auxiliary technology	GPS data can be combined with data from a variety of different sensors/technologies: accelerometers, compasses, gyros, pedometers, and temperature sensors, light sensors, electrocardiogram and blood glucose monitors, skin conductivity monitors, Wi-Fi networks and GLONASS.	Chose auxiliary technology according to the objectives of the tracking project.
Logging frequency	Different frequencies are used in the literature ranging from one position every second to several minutes or hours between each position.	Choose logging frequency depending upon the technology available, the objective of the projects and the power consumption.

Table 7.3: The table shows a number of key issues to reflect upon when planning a GPS tracking project (suite)

Issue	State of the art	Things to reflect upon
Battery life	The battery life of different GPS devices and smart phones solutions varies.	What battery life is needed given the length of the study? Impact of different logging frequencies, impact of the use of auxiliary technologies and impact software design in the case of smart phone apps.
Precision/ Quality	Different approaches to measuring precision and quality, but overall three dimensions: geographical precision, completeness of trips and number of trips tracked in relation to total amount of trips conducted by the respondent.	The quality of the GPS device used, and whether it is a differential GPS device. Education of respondents in relation to how to carry the device or install the device in vehicles. Choice of threshold for holes in data, and analysis of how many trips that was tracked in relation to how many there were conducted.
Data collection methodology		
Sample group, size and length of tracking period	Different target groups are found in the literature, ranging from households in general to specific groups such as children, youngsters and elderly people. The sample size also varies from around a dozen of people to several thousands and so does the tracking period, which varies from a few hours to several months.	The socio-economic characteristics of the target group in relation to recruitment, motivation and technology. The sample size and length of tracking period seen in relation to the objectives of the investigation.
Passive vs. Active tracking	In passive studies respondents only carry the GPS unit, which minimizes the burden placed on the respondent, but means that trips, modes and purposes have to be derived from the GPS data. In active studies respondents answer questions before and/or during and/or after the tracking.	Is an active design necessary to capture the data needed to reach the objective of the study? If so, how should the questions be formulated to keep the work load on the respondent to a minimum, and how and when should the respondent be asked and how should the respondent answer?
Motivation of respondents	Without motivated respondents a tracking project will not result in high-quality data.	How is the respondent motivated to participate, and how is the motivation maintained throughout the tracking project?

Table 7.3: The table shows a number of key issues to reflect upon when planning a GPS tracking project (suite)

Issue	State of the art	Things to reflect upon
Business model	It is important to design the business system around a tracking project so that the technology, the market (respondents) and the business needs come together in a perfect combination.	How do we design the technology, the communication with the respondents, our own organizational structure etc., so that the respondents gets a valuable experience from participation and thus is motivated and that we as researchers obtain the data we need?
Analysis		
Trip	Several methods used to identify trips in GPS data, and identification of trips depends both on logging frequency and availability of data from auxiliary technologies. One recurrent issue is how long time a stop should last before it qualifies as the end of a trip (and beginning of a new), as well as how long (geographically or time wise) a trip should be to qualify as a trip.	What is the logging frequency? Are data from auxiliary technologies available, which can be used to identify trips? How long should a stop at a given location last to qualify as the end of a trip? How small can a trip be, geographically and time wise?
Mode	Different methods is proposed in the literature, some relying on pure GPS data, some relying on a combination of GPS data and accelerometer data and some relying on GPS data in combination with a variety of spatial and statistical data.	What is the logging frequency? What auxiliary technology is used and what complementary data are available?
Purpose	Different methods are proposed in the literature, and they vary according to need for auxiliary data, for example GIS data on land use, road networks, and addresses.	What is the logging frequency? What auxiliary technology is used and what complementary data are available?

With these issues derived from the GPS literature it is now time to return to Table 7.1, and reflect upon the use of other new technologies, such as GSM tracking.

7.4 GSM and other new technologies

Seen from the SHANTI members' perspective it appears that GPS tracking still guarantee the best combination of costs, quality, accuracy and continuity. The other have different drawbacks that make them more or less suitable in different contexts, and it should be noted that there are some concerns about privacy issues related to the use of non-anonymous tracking devices.

What is also important to note in Table 7.1, is the point that the sample size in GSM tracking may potentially be huge; thousands or even millions of people may be tracked this way. Further, it could be added, that the tracking time may also be huge compared to GPS tracking. While few studies utilizing GPS reach durations of months of tracking, GSM tracking may be ongoing for years, since it is only limited in length by the age of the log files kept by the network operators who collect the mobile data as well as how long respondents keep their network contracts.

As discussed in section 7.3.1 a relatively big effort has gone into development of algorithms for trip, mode and purpose identification, and significant progress has been made. Discussing these issues more general in relation to different new technologies as specified in table 1, the SHANTI participants at the meeting arrived at the following advices regarding trips, mode and purpose:

- Trips: The identification of the different trips and portions of trips is basic information that depends on the type of survey (fleet or personal survey) and on the different definition of trips and its subdivisions used in given studies.
- Mode: A consistent number of experiences proved the possibilities to successfully derive mode of transport from raw GPS data.
- Purpose: The derivation of purpose still represents the biggest challenge for researchers due to its complexity and need for external information.

The discussion about different methods for deriving mode and purpose from GPS data also showed that several different methods exist for processing GPS data, and there is no consensus on best practice. Further, when including other new technologies in the discussion, i.e. the ones in Table 7.1, the picture becomes even more diffuse. Therefore the advises given by the participants at the SHANTI meeting in relation to post-processing of data collected using new technologies is that the main post-processing tasks should be as follows:

- Cleaning: To get rid of bad data.
- Smoothing: To clean possible noise in the dataset.
- Derivation: The main step of the analysis, which is fulfilled using rule-based or statistical/stochastic methods, with the help of training data, tuning the process through quality index threshold (e.g. membership function acceptable values) setting derivation parameters (e.g. mode of transport's characteristics) and/or using external information sources (e.g. GIS layers).

The main limitations of the post-process depend on the data continuity (for the tracking devices), availability (for the external sources) and/or the necessity of data implementation of different sensors/technologies to overcome all the possible

technological problems. Again, different technologies have different characteristics, as Table 7.1 highlights.

The participants at the SHANTI meeting also discussed how different new technologies could be used in surveys and the possibilities and challenges relating to this, and arrived at five issues relating to this. Firstly, there is the matter of acceptance. New technologies are in general well accepted by interviewers but there are still issues among respondents, who prefer traditional survey methods. In particular, some socio-economic groups are more or less willing to participate in surveys that involve tracking with new technologies, which causes new biases. Therefore new research is needed which focus on what type of respondents' different new technologies can reach, and also what biases that occurs in which setups. The acceptance issue is related to privacy concerns and lack of control of personal data. Possible remedies include a better explanation of the survey objectives and methods, a better training for interviewers and the possibility for respondents to have more control of their personal data. Returning to section 7.3.1 here, it should be noted that a number of issues important in relation to acceptance was highlighted, for example the issue of how to motivate the respondents to participate as well as the issue of the business system, i.e. how the GPS tracking is structured to provide the respondent with a valuable experience which in turn secures participation. The second issue is privacy; privacy can affect data use depending on privacy regulation, and can even prevent the use of geocoded personal data. A possible solution is data-fuzzyfication that will degrade data quality and relegate GPS to a support for self-reporting diaries. The third issue is operational issues related to the managing and handling of devices by respondents. The most effective way to get rid of problems related to those aspects is to design simpler solutions and make them as passive as possible. It should however be noted, as discussed in section 7.3.1, that the use of an active design also entails certain advantages. The fourth issue is organizational challenges which was also discussed in section 7.3.1; a number of challenges relate to the organization of a travel survey using new technologies, such as the definition of operating instructions, the number of devices that need to be used and their update rates, possible confusion within households and the send-out and pick-up procedures. Possible solutions to minimize the impacts of these factors include recruitment training and prompted recall surveys. The fifth issue is costs; it is very difficult to compare cost between the different available survey tools (traditional tools, GPS, GPS as supplement of report diaries). Currently, GPS surveys are apparently more expensive than active report diaries due to economies of scale. Nonetheless, they allow researchers to easily collect multiday reports, to reduce sample number and provide same data format across surveys and countries. The big drawback is the necessity of prompted recall surveys unless different definitions of purpose information are identified.

With these relatively general points on new technologies in general in mind, it is time to turn focus on GSM tracking, which is the technology after GPS tracking where most experiences has been collected. Mobile network data is a very pervasive means of data collection and theoretically very effective for enhancing traditional data collection surveys. It is also important to note that this technology is a source of information by itself, because it provides a great amount of associated

information related to the data stored by the mobile data carrier (socio-economic, cell-phone use, transactions) as well as by handsets. To summarize, the main available information includes:

- Cell-phone contract information.
- Transaction information.
- History of the activity of handsets.
- Location information.

Identification of the precise location of the respondent and identification of trips, trip mode and purpose are the main issues in using mobile phone data as survey tool today. It is relatively easy to derive this information from GPS tracks, but it is still a challenge to do so in mobile phone data. Beside this issue, the availability of the mobile phone data is also a concern, especially considering privacy regulations, which vary from country to country. The data universe regarding mobile network operators, handset providers, app providers and mobile websites are further very fragmented. Despite these drawbacks, the use of mobile network data remains an attractive opportunity, as it provides the greatest penetration among potential respondents, compared to all other means of data collection using new technologies. Using the mobile network data, it is indeed possible to study the time framework of mobility, but there are also issues related to the fact that penetration is not homogeneous among users and data gathering can be different among different mobile network operators.

Having now presented an overview of new technologies in Table 7.1, discussed GPS tracking in detail, and the use of other new technologies in general, it is now time to end this chapter with some reflections on the future for travel surveys and the use of new technologies.

7.5 Reflections on the potential of travel surveys and new technologies

The changing datascape and the emergence of the new technologies discussed in the previous sections make it necessary to reflect upon the future use of travel surveys and new technologies in travel behaviour research. Discussions at SHANTI meetings revealed that with the advent of new technologies give, the future brings not only possibilities of collecting known types of travel behaviour data more efficient, i.e. collecting data on trips, modes and purpose more efficient than before, it also makes it possible to collect new types of data which may make it possible to answer new questions within the travel behaviour research field. Further, it is not only the transport researcher, which gains the possibility of collecting new types of data, a variety of organizations and companies throughout society, are already collecting data at staggering paces, companies such a Google, Apple and Facebook are compiling huge datasets that may also yield new insights into travel behaviour. Even the public is creating data through so-called volunteered geographical information initiatives (Elwood, Goodchild, & Sui 2012; Goodchild 2007). In other words, as travel behaviour researchers we are facing a situation, where we have a variety

of different technologies available, which makes it possible to collect both known types of data on travel behaviour as well as new types of data on such. Further, throughout society, data is also collected and stored by public organizations, private companies and even individual citizens. This makes it necessary to reflect upon how the future use of travel diaries and new technologies may look as seen from a travel behaviour research perspective. At the SHANTI meeting in Copenhagen in October 2012 the participants therefore discussed the future use of new technologies and travel surveys seen in the light of Big Data.

Big Data is a concept which has gained momentum in recent years within science in general, especially with a number of articles in Nature in 2008, as well as in a number of academic fields, for example computer studies, biology, medical science, physics as well as business and economics. The basic idea is, that today we are seeing the emergence of new datasets in society, collected by private as well as public organizations, which are so vast in size that they demands new methods and technologies for data management and analysis and simultaneously provides the possibilities for new insights and new knowledge to be created (Doctorow 2008; Donovan 2008a; Donovan 2008b; Frankel and Reid 2008; Goldston 2008; Graham-Rowe 2008; Howe, Costanzo, Fey, Gojobori, Hannick, Hide, Hill, Kania, Schaeffer, & St Pierre 2008a; Howe et al. 2008b; Jacobs 2009; LaValle, Lesser, Shockley, Hopkins, & Kruschwitz 2011; Lee 2008; Lynch 2008a; Lynch 2008b; Nelson 2008; Waldrop 2008).

The current discussion on Big Data is not so much what can be done with Big Data, but more preliminarily: what challenges and opportunities does Big Data present to society? In 2012 the US government thus initiated a 200 million dollar "Big Data Research and Development Initiative" to explore this issue (www.whitehouse.gov 2012), and also in 2012 year the World Economic Forum published the report "Big Data, Big Impact", in which it was argued that a flood of data is created daily and governments, public organizations and private companies need to start using the possibilities this presents (World Economic Forum 2012). Companies are also joining the Big Data discussion, McKinsey thus argued in a 2011 report, that Big Data is going to be the driver for innovation, competition and productivity in the future and that it will create the demand for hundreds of thousands, possibly millions, of new jobs in the US.

It is not the focus of this chapter to discuss the potential of Big Data; the goal is only to reflect on the future of travel surveys seen in the light of Big Data. Therefore, at the SHANTI meeting in Copenhagen, the discussion was kicked off with a number of provocative statements about how Big Data might change the use of travel surveys and new technologies, and in the following we will present and reflect upon some the points made during the following discussion at the meeting. These points will illustrate some perspectives on what potential travel surveys might have in the future in combination with other new technologies. It should be underscored that the following points are only reflections about what the future might look like, as seen from the standpoint of SHANTI members in 2012.

Firstly, traditional travel surveys are still needed, because there is a need for comparisons between countries, regions, cities, etc. Traditional travel surveys are

in this regard understood as data collections where travel behaviour researchers actively drive the data collection, whereas with Big Data sources other actors, for example public or private organizations, collect the data and then later analysed by travel behaviour researchers. A tendency is apparently that it is becoming increasingly difficult to obtain answers from respondents in traditional travel surveys, and further, funding for traditional travel surveys is also becoming increasingly sparse in some contexts. Whether the funding issue will change in future is difficult to estimate, but it seems that it is becoming increasingly difficult to obtain funding for national travel surveys that are made mainly for general purposes, whereas there is still a demand for specialized travel surveys made for example to clarify impacts of specific infrastructure projects and other political decisions.

This also leads to the second point, which is that traditional surveys are still needed because Big Data is not, at the current time, able to deliver answers to the questions that are current answered through the use of travel surveys. However, what Big Data might supplement to travel surveys is more detail. Originally travel surveys were not made for understanding travel behaviour; they were made to estimate the amount of travel. The link between travel surveys and travel behaviour is therefore relatively weak today, and by linking travel surveys to Big Data a better understanding of travel behaviour might emerge. And this leads to the link between travel surveys and Big Data, which is the third point.

Thirdly, it seems that traditional travel surveys can potentially play an important role in relation to evaluating the potential of new data sources. Maybe parts of the information which is collected in the travel surveys today is already available in Big Data today but we do not know how to identify it, obtain it, structure it and analyse it. Therefore in coming years an effort should be made to investigate what kind of answers that is possible to obtain from different Big Data sources in relation to travel behaviour questions, and in this regard data from traditional travel surveys may be an important tool for evaluating the potential of different Big Data sources.

Fourthly, Big Data comes from many different sources, which causes challenges both in relation to comparing data from different sources as well as in relation to linking the data with real people, and get the attributes of the people into the analysis to draw a picture of the actual people involved. Further, Big Data is still mainly selective, and therefore some travel behaviour researchers are reluctant to use it, because it gives part of the big picture, bit only a section, not the whole picture. I might give good view upon specific sections of the big picture, but the overview of the big picture is currently missing. And this is one area where the traditional travel survey might have an important role in the future; to act as the glue, which glues the different sections together to a unified picture. Traditional travel diaries may in other words be the backbone that makes it possible to join data from different big data sources throughout society to unified pictures that gives us new insights into travel behaviours. As such the role played by traditional travel surveys may be changing.

Fifthly, up to now we have been relatively question-oriented in our approach to data. If we use Big Data this will change towards a more data oriented approach, where focus will be moved to the answers that could be found in this data. This

is another paradigm within travel behaviour research, and it is unclear which of these two approached that is the best.

Sixthly, private companies own a large part of Big Data, and therefore the data is expensive, and maybe not accessible to travel behaviour researchers. This means that there is a need to help those who own big data to use it for travel studies purposes in a way which don't compromise laws or cause loss of business opportunities, and thus work on establishing practices and possibilities for sharing and using such data in travel behaviour research.

Seventhly, looking 25 years ahead from now in a long-term perspective, it seems plausible that big data will play an important role in travel behaviour research. However, as travel behaviour researchers we also need to focus on how we are going to proceed in short to medium time horizon. This involves encouraging existing customers of travel surveys, public and private, to think about other data sources which may answer the questions posed today. It also means putting focus on the business models behind travel behaviour research and data collection, and the funding structures for such research. Further, it also means fusing different types of data, a process that happens a lot in traffic data already, but is less normal in for example the planning spheres. Shortly put, the data is here, and the world is changing, therefore we should not only reflect on where this might will lead is 25 years from now, we should also start to explore new possibilities today and move in new ways tomorrow.

To round of, the conclusion on this chapter must be, that the datascape for travel behaviour research is changing, a number of new technologies are available for data collection, and this chapter has explored hew these can supplement travel surveys, with a special focus on GPS tracking, and the overall picture emerging is that there is still a need for travel surveys although the way in which travel surveys are used in relation to new technologies and the role they play in relation to travel behaviour research may be changing.

Conclusion

SHANTI has been an opportunity for cooperation that has brought together most of the leading experts in the travel survey research field in Europe. The state of the art in this field is widely differentiated across EU countries, ranging from situation where no such kind of activity has ever been implemented to countries where there is an established tradition in this field. In the latter case, stakeholders' (and funding bodies) primary interest is to preserve the longitudinal comparability of survey results from different time periods within their country. Therefore, the ex-ante standardisation of survey instruments seems not feasible, maybe not even convenient in such situation.

In other words, merely proposing a standardisation through a top-down approach or an "ideal questionnaire" would therefore have been of little utility and impact. A bottom-up approach has instead been proposed within SHANTI, where the focus is on the gradual convergence through an evolution from the present state of the art, aimed at the maximisation of the (ex-post) comparability of survey results. While standardisation is a concept that can be referred to the data collection process, comparability is more linked with the outcome of such activity. Thus, it depends on the actual usage of those data: if the focus is to build descriptive statistics on travel availability and use, comparability implies the ability to meaningfully match national travel statistics and build pan-European ones (e.g. daily trips/person). Within SHANTI, this approach has been taken to define comparability, thus letting aside other more challenging issues such as the possibility of pooling observation of several NTS datasets to feed a pan-European travel demand model.

The notion of comparability has informed the whole set of SHANTI activities. Its main results have been summarised in this report, but dissemination activities went also well beyond this document. The whole project output can be in fact structured as follows:

1) At a first level, SHANTI has provided a set of information tools to the transport researchers, transport decision makers and stakeholders' communities. Beyond the comparative analyses on NTS that are contained in the present report, we mention here the SHANTI website (http://shanti.inrets.fr/) with a lot of documents and background material that has been analysed during the project and the SHANTI wiki (http://shanti-wiki.inrets.fr/index.php/Main_Page) that provides an easily accessible and flexible source of information for most of European NTS that have been implemented in past decades. To the best of our knowledge, this is the most complete compilation on the main characteristics of such NTS openly available on the web. The innovative choice of setting up a wiki would allow an easy update of its contents as time passes, beyond the project duration.
2) SHANTI has elaborated a set of recommendations aimed at harmonising existing NTS and improving the comparability of their results. Under this point of view, on one hand we indicated ways to achieve this goal through appropriate ex-ante survey planning decisions, on the other we conducted

an exercise aiming at an ex-post harmonisation of figures from existing NTS to show how many tricks concerning the definition of quantities are often overlooked in naïve approaches.

3) SHANTI has also presented guidelines for realizing NTS that could be particularly useful for those countries not yet having such tool and planning to implement one. A review of the survey characteristics that represent the best approach according to research outcomes is presented. Beyond this, a consultation with a large panel of experts both belonging to the SHANTI group and to TRB Committee on Travel Survey Methods in the U.S. allowed to identify which are the actual contents of a questionnaire that are deemed more important.

The relevance of such results is given by the fact that comparability issues are likely to become more and more important as time passes. This is due to the increasing need of having a common baseline for observing mobility in Europe, in order to foster the European Research Area also in the transport sector, to support trans-national funding and investment decisions on transport systems and to inform decisions on structural, cohesion and convergence funds also beyond the transport domain. Moreover, global warming is a growing concern, and the 2011 White Paper makes several measures to cope with it, which it would be important to monitor.

However, even letting aside such European perspective, it is important to note that passenger transport data comparability issues are arising worldwide also on different grounds (Armoogum and Diana, 2013):

- New data collection technologies are in fact inducing changes in survey protocols even at national level. In current budgetary restrictions these new opportunities are sometimes inappropriately seen as a mere occasion to save money and are therefore highly sponsored, in comparison with more traditional data collection method. However, there is a risk to overlook comparability issues that arise when the same piece of information is collected through different methods (e.g. trip distance through GPS or by asking the traveller).
- Multi-protocol travel surveys could be necessary in the future to build a sample that is representative of the population in any given area. For example, highly mobile, permanently connected population segments could be reachable only through the web, and an increasing portion of households does not have a landline phone. On the other hand, population aging and raping technology evolutions are widening the digital divide, thus keeping the need for telephone and face to face survey protocols. Also in this case, comparability of data gathered through different channels needs to be studied.

To sum up, current travel survey methods will probably in any case be forced to change, also not considering policy actions at the EU level. This represents on one side a challenge for researchers that will have to ensure that data quality is not deteriorated. On a more positive viewpoint, such innovation drivers represent

also an opportunity to guide the foreseeable evolution processes at a national level in such a way that the comparability among different NTS will increase in the future, making the whole system converge towards some commonly agreed best practices.

Four years ago, the initial hypothesis of SHANTI COST Action was that survey results could be harmonised all over Europe by using the same new technology survey instruments (e.g. GPS or GSM). Indeed, although most of National Travel Surveys are conducted in Europe, each country had adopted its own methodology and is reluctant to modify it, because an important objective is the assessment of trends, for which the best method is a continuous data collection (the Netherlands since 1978, Great Britain since mid-1988, Denmark since 2006, and even a panel survey MOP in Germany since 1994). Thus, little convergence is observed between countries, despite a generalisation of Computer Assisted methods (CAPI, CATI, CAWI) and of mix modes protocols, which make results more robust and which make the survey more friendly to respondents, who can chose their preferred survey mode.

Harmonisation can be conducted in different ways. For instance in France for urban and local mobility surveys, a trunk questionnaire and the methodology are imposed and checked by CERTU,, which is a condition for the survey to be subsidised by the National State. At European level, EUROSTAT is promoting common definitions and recommendations (e.g. protocol) for different kinds of surveys:

- on Heavy Trucks in the transport sector,
- on family budget or time use for households

but no harmonisation is planned for Personal Travel Surveys. Some information can be derived from time use surveys (e.g. proportion of immobile, trip duration or frequency), but it is hardly comparable with the results from travel surveys (Hubert et al., 2008) and no information can be drawn on trip distance, modal split or long distance travel. In fact, many colleagues are very reluctant to a priori harmonisation rules, especially in the emerging and rapidly evolving domain of new technologies.

However, especially for countries in the Eastern and Southern parts of Europe, which have not yet conducted any travel survey at national level, we propose a minimum set of questions and simple recommendations, which could be published as a set of guidelines cards (chapter 5). On the basis of so different surveys, post harmonisation is not easy; however, detailed results are presented for the most recent surveys in 11 countries (cf. chapter 4). The assessment of trends had been planned and should be useful for monitoring the objectives promoted by the White Paper, but quite heterogeneous periodicity in data collection and a more and more volatile economic situation make this exercise more complex than expected.

This COST Action has produced many more results, which could not be developed in the final report, for instance on vehicle-based surveys. The Heavy Truck survey harmonised by EUROSTAT gives a good example of comparable data all over Europe, although it would be useful to promote a methodology for including additional information on fuel consumption. More attention should also be

dedicated to Light Duty Vehicles, which generate still increasing traffics despite of peak travel for cars and of recessions for heavy trucks. Their mix function between households and companies make it difficult to describe them through a single survey, but there are good examples among the four European countries conducting specific surveys on LDVs: the German questionnaire could be an example for generalising this type of survey.

Ackowledgements

We wish to thank COST for supporting the network and the publication of this book. COST is a unique platform where European researchers can jointly develop their own ideas and new initiatives across all scientific disciplines through trans-European networking of nationally funded research activities. Based on a European intergovernmental framework for CO-operation in Science and Technology with 35 Member Countries and one Cooperating State (see “explanation of terms used in this document”), COST has, since its creation in 1971, contributed to closing the gap between science, policy makers and society throughout Europe and beyond.

The COST mission is to enable breakthrough scientific developments leading to new concepts and products and thereby contribute to strengthen Europe’s research and innovation capacities. COST contributes to the objective of strengthening the scientific and technological bases of the European Research Area (ERA) by encouraging researchers to share, create and apply knowledge.

We also wish to mention all young researchers who actively participated (with STSM) and provided valuable work in this action including José Carlos Bernabé Gascón (UPV, DT); Lissy La Paix (UPM, TRANSyT); Begoña Muñoz (UPM, TRANSyT); Peter Ottmann (KIT, ITS); Kristian Reinau (Aalborg University); Frédéric Schmitz (CEPS/INSTEAD; Petr Senk (CDV); Natalia Sobrino (UPM, TRANSyT); Jana Stachetzki (KIT,ITS); Maria Tébar de Elías-Ostúa (UPM, TRANSyT); Jean-David Timsit (Ifsttar-AME-DEST); Lycurgo Vidalakis (Politecnico di Torino, DITIC); Toky Randrianasolo (Ifsttar-Ame-Dest) and Shuning YUAN (Ifsttar-AME-DEST).

Finally we extent final thanks to Thierry Goger and Carmencita Malimban of the COST Office.

References

Armoogum, J. and Diana, M. (2013*)* Workshop synthesis: comparative research into travel survey methods, in: Zmud, J., Lee-Gosselin, M., Munizaga, M and Carrasco, J.A. (eds) *Transport Survey Methods: Best Practice for Decision Making*, Emerald, Bingley (UK), pp. 337-346.

Armoogum, J., Roux, S., 2007. *Mise en perspective des Enquêtes Nationales Transports*

1973/74 – 1981/82 – 1993/94 et 2007/08. Rapport final Ifsttar J07-17. Numéro MEDAD – SG/DRAST: 07 MTS 018.

Armoogum, J., Roux, S., *Calibration Strategies to Correct Nonresponse in a National Travel Survey.* Transportation Research Record 2246.

Armoogum J., Hubert J.-P., Bonnel P., Madre J.-L. 2007, *Préparer la prochaine enquête nationale transport avec un regard international*, Rapport de convention n° 03 MT 68 pour la DRAST Prédit.

Auld, J., Williams, C., Mohammadian, A. and Nelson, P., 2009. *An automated GPS-based prompted recall survey with learning algorithms*. Transportation Letters: The International Journal of Transportation Research (2009) 1: (59-79).

Axhausen, K.W. (1995) Travel diaries: an annotated catalogue, 2nd edition, Working Paper, Institut für Straßenbau und Verkehrsplanung, Leopold-Franzens-Universität, Innsbruck..

Bernabé J.C. and Ruiz, T., 2010. Calidad de los modos a pie y en bicicleta. *Tolerancia al cambio modal.* Congreso de Ingeniería del Transporte CIT2010, Madrid 5-7 July 2010 (In Spanish).

BGC, 1985. *Analyse panelmeting ten behoeve van het onderzoek Tarievenplan* (Analysis of panel wave for the Fares policy Analysis), Report for Projectbureau IVVS, The Hague. (In Dutch).

BGC, 1991. *Het Longitudinaal Verplaatsingsonderzoek - Kenmerken en Gebruik*. Bureau Goudappel Coffeng, Projektbureau IVVS. Deventer (In Dutch).

CERTU, 2009. *Household Travel Survey "Certu standard" Methodological guide*.

Chlond, B., 2004. *The German Mobility Panel. Intention and Conceptual Approach*. COST 355, Namur 01-12-2004.

Berri, Akli, Chlond, Bastian, Christensen, Linda, Dargay, Joyce, Malasek, Jacek, Ottmann, Peter, Vythoulkas, Petros, 2008: The Automobile*. Changing Behaviour towards a more Sustainable Transport System* (ISBN: 978-3-9811078-2-1), pages: 29-59, Institut für Verkehrswesen, Universität Karlsruhe, Karlsruhe,

Christensen, Linda, 2013*: Web interviews as part of a modern Household Survey - evaluation and highlights of technical solutions.*

Christensen, Linda, 2006*:* Possible Explanations for an Increasing Share of No-Trip Respondents. In: Stopher, P. And Stecher, C: Travel Survey Methods. Quality and Future Directions (ISBN: 0080446620), 2006, Elsevier Science, Amsterdam - Book chapter

Christensen, Linda, 2005: *Possible Explanations for an increasing Share of No-Trip Respondents.* Paper Presented at: Trafikdage på Aalborg Universitet 2005, Aalborg
http://www.trafikdage.dk/td/papers/papers05/Trafikdage-2005-443.pdf

Clark, A. and Doherty, S. (2008) Use of GPS to automatically track activity rescheduling decisions, *8th International Conference on Survey Methods in Transport*, Annecy, France, May 25-31, 2008.

Dargay, J., Hanly, M., Madre, J.L., Hivert, L. and Chlond, B., 2003. *Demotorisation seen through panel surveys: a comparison of France, Britain and Germany*. 10th International Conference on Travel Behaviour Research. Lucerne, 10-15 August, 2003.

Dargay, J.M., 2005. *The journey to work: an analysis of mode choice based on panel data*. European Transport Confererence, 2005.

Dickinson, S., Melbourne, L., 2013: *Immobile proportion in the National Travel Survey (Great Britain.*

EEA, 2013: EEA reference grid samples for projection ETRS89-LAEA 52N 10E, http://www.eea.europa.eu/data-and-maps/data/eea-reference-grids

Ewing, R., Cervero, R. 2010. *Travel and the Built Environment. A Meta-Analysis. Journal of the American Planning Association* 76, 265-294

European Communities, 2005. *Comparable time use statistics National tables from 10 European countries.* ISBN 92-894-8553-1. ISSN 1725-065X. Cat. No KS-CC-05-001-EN-N.

European Communities, 2006. *Comparable time use statistics. Main results for Spain, Italy,*

Latvia, Lithuania and Poland. ISBN 92-79-01682-2. ISSN 1725-065X. Cat. No KS-CC-06-006-EN-N.

Federal Highway Administration, 1994. *Study Tour for National Travel Surveys.* Report available on: http://ntl.bts.gov/DOCS/surveys.html.

Frei, A., Kuhnimhof, T. and Axhausen, K.W., 2010. *Long distance travel in Europe today: Experiences with a new survey*. Transportation Research Board Annual Meeting 2010 Paper #10-2031.

Fricker, R., 2006. *Sampling Methods for Web and E-mail Surveys.* Naval Postgraduate School.

Golob, T., Kitamura, R. and Long, L., 1997. Panels for transportation planning. Methods and applications. Kluwer academic publishers, Massachussetts USA.

Houée, M. and Calzada, C., 1996. *Impact du TGV Nord Européen sur la mobilité* (I), Notes de Synthèse, SES nº102 (In French).

Houée, M. and Calzada, C., 1997. *Three years of continuous panel surveys on the impact of*

North European High Speed Train on mobility behavior: main results and essential methodological findings. European Transport Confererence, 1997.

ICC/ESOMAR 2008, *International Code on Market and Social Research*

IfV, 2005. *Die intermodale Vernetzung von Personenverkehrsmitteln unter Berücksichtigung der Nutzerbedürfnisse* (INVERMO). Schlussbericht. http://verkehrspanel.ifv.unikarlsruhe.de/informationen/indexinformationen.htm Accessed September 2011. (In German)

Kitamura, R., 1990. *Panel analysis in transportation planning: An overview*. Transportation Research Part A: General November 1990: (Volume 24, Issue 6) p. 401-415.

Kuhnimhof, T., Bastian, C. and Zumkeller, D. 2006. *Nonresponse, selectivity, and data quality in travel surveys: Experiences from analyzing recruitment for the German mobility panel*.Transportation Research Record: Journal of the Transportation Research Board. Volume 1972 pp 29-37. 2006

Link, M., Battalglia, M., Martin, F., Osborn, L., Mokdad, A., *A comparison of address-based sampling (ABS) versus random-digit dialing (RDD) for general population surveys.* Public Opinion Quarterly, Vol. 72, No. 1 2008, pp. 6–27.

Madre, J.-L., Axhausen, K. W. and Brög, W., 2007 *Immobility in travel diary surveys. Transportation* 34: pp. 107-128.

Matiaske, W., Menges, R. and Spiess, M. (2011). *Modifying the rebound: It depends! Explaining mobility behavior on the basis of the German socio-economic panel*. Energy Policy Available online 23 February 2011: () p. –

Ministerio de Fomento, 2002. http://www.fomento.gob.es/ Accessed: September 2011.

Ministerio de Fomento, 2007. http://www.fomento.gob.es/ Accessed: September 2011.

NCRHP report 571, 2008. *Standardized Procedures for Personal Travel Surveys.* National Cooperative Highway Research Program. Transportation Research Board of the National Academies

Nielsen, T.S., Hovgesen, H.H., and Lassen, C., 2005: *Explanatory mapping of commuterflow in England and Wales, Paper presented at the RGS-IBG Annual international conference* 2005, London

Næss, P. 2005. Residential location affects travel behavior—but how and why? The case of Copenhagen metropolitan area, Progress in Planning 63, 167-257

Nielsen, T.S., Hovgesen, H.H., and Lassen, C., 2005: Explanatory mapping of commuterflow in England and Wales, Paper presented at the RGS-IBG Annual international conference 2005, London

Observatorio de la Sostenibilidad –OSE- (2007*). Informe de la Sostenibilidad en España*. http://www.sostenibilidades.org/sites/default/files/_Informes/anuales/2007/sostenibilidad_2007-esp.pdf

Ortúzar J. de D., Armoogum, J., Madre, J.L. and Potier, F., 2010. *Continuous Mobility Surveys: The State of Practice*, Transport Reviews Vol. 31, Iss. 3, 2010.

Roux, S., 2007-2008.*Correction de la non-réponse dans l'Enquête Nationale sur les Transports et les Déplacements 2007-08.* Mémoire master recherche II. IDUP-Université Paris I.

Ruiz, T., 2004. *A review of general and mobility panel survey methodology: some findings*. 'Universidad Politécnica de Valencia' Working Paper.

Ruiz, T., Bernabé, J.C., Jorba, J. and González, R.C., 2010. *Aportación a las metodologías de recogida de datos de movilidad mediante el empleo de las nuevas tecnologías (Contribution to the mothodologies of mobility data collection through the use of new technologies).* Congreso de Ingeniería del Transporte CIT2010, Madrid 5-7 July 2010 (In Spanish).

Ruiz, T., Bernabé, J.C., García, P. and Colomer, G., 2011. *Measuring the impact of travel behavior change programs on the activity scheduling process.* 9th International Conference on Survey Methods in Transport (ISCTSC), Termas de Puyehue, Chile, November 14-18, 2011.

Schoenduwe, R. and Lanzendorf, M. *The potential of regional panel surveys: a comparative analysis of the Frankfurt/Rhinemain panel and national household travel surveys. A working paper*. 12th WCTR, July 11-15, 2010 – Lisbon, Portugal.

Tourangeau, R., Zimowski, M. and Ghadialy, R., 1997. *An introduction to panel surveys in transportation studies*. Federal Highway Administration report.

Trivector Traffic, 2006. *Changes in travel habits in Stockholm County Effects of the Stockholm Trial*. Revised final version Report 30-08-2006.

U.S. Bureau of Labor Statistics Division of Information Services. *BLS Information. Glossary.* February 28, 2008. Retrieved 2009-05-05.

Van Wissen, L.J.G. & Meurs, H.J. (1989). *The Dutch Mobility Panel: Experiences And Evaluation*. Transportation 16: 99-119.

Zumkeller, D., 2004. The German Mobility Panel. www.mobilitaetspanel.de Accessed

September 2011.

Zumkeller, D., Chlond, B. and Kagerbauer, M., 2008. *Regional Panels Against the Background of the German Mobility Panel – An Integrated Approach*. 8th International Conference on Survey Methods in Transport: Annecy, France, May 25-31, 2008

Travel Surveys:

Barcelona: EMQ 2006

Belgium: http:// www.beldam.be /

Denmark: Transportvaneundersoegelsen (TU) – (Tavel behaviour Survey) http:// www.dtu.dk/centre/Modelcenter/TU.aspx

Finland: HLT 2010-11:

www.hlt.fi/

http://portal.liikennevirasto.fi/sivu/www/e/fta/research_development/national_travel_survey

Germany:

Infas, DLR (2010), MiD 2008 - Mobilität in Deutschland. Methodenbericht.

Mobilität in Deutschland: MID 2008: National Transportation Surveys Activities in Germany; TRB Annual Meeting 2012, Session 483 P12-6949

Great Britain:

https://www.gov.uk/government/organisations/department-for-transport/series/national-travel-survey-statistics

http://assets.dft.gov.uk/statistics/series/national-travel-survey/nts-gps-analysis-report.pdf

Luxembourg: http://mobil-t.ceps.lu/project/emf.cfm

Norway: RVU 2009

Spain:

MOVILIA, nota metodologica Ministerio de Fomento:

http://www.fomento.gob.es/MFOM/LANG_CASTELLANO/ESTADISTICAS_Y_PUBLICACIONES/INFORMACION_ESTADISTICA/Movilidad/Movilia2006_2007/

SHANTI-SPANISH participants: *Mobility Surveys in Spain*

Sweden: RES 2005-06

Switzerland: Mikrozensus 2010

Web sites:

http://shanti.inrets.fr/ Documents Center

http://shanti-wiki.inrets.fr/index.php/Main_Page

THE ON-LINE TRAVEL SURVEY MANUAL: http://www.travelsurveymanual.org/

http://maps.google.fr/

http://mobilitaet-in-deutschland.de

http://www.esomar.org/uploads/public/knowledge-and-standards/codes-and-guidelines/ESOMAR_ICC-ESOMAR_Code_English.pdf

Appendix A: Survey method of NTS in European Countries

Country	Year	Survey mode	Computer-aided interview	Contact before survey	Response rate individuals having described their mobility / individuals in the scope
Austria	1995	Postal delivery and personal collection of questionnaire	No		77%
Belgium	1999	Postal self administered + phone call reminder	CATI for phone call	Official letter before survey	33%
	2009	Postal self administered + phone call reminder - Sub-sample face to face	CATI for phone call	Official letter before survey	
Denmark	Before 2003	Telephone survey	CATI	Official letter before survey	67%
	From 2006	Web + Telephone survey	CAWI/CATI, same questionnaire for both	Official letter before survey	62%
Finland	2004-05	Telephone interview	CATI	Official letter with simplified trip diary form before survey	67%
	2010-11	Telephone interview	CATI	Official letter with simplified trip diary form before survey	56%
France	1993-94	2 visits, face-to-face + self administered vehicle diary	No	Official letter before survey	82%
	2007-08	2 visits, face-to-face + self administered vehicle diary (GPS possible)	CAPI	Official letter before survey	78%

Appendix A: Survey method of NTS in European Countries (suite)

Country	Year	Survey mode	Computer-aided interview	Contact before survey	Response rate individuals having described their mobility / individuals in the scope
Germany	2002 MID	Telephone survey when phone number is available (60%); if not postal survey	CATI for telephone survey	Official letter before survey	42%
	2008 MID	HH level: mainly telephone (~90%), some online (~5%) or written questionnaire (by post (~5%); person/ trip level: only telephone	CAWI option for HH interview (sub-sample); CATI for telephone interviews on HH, person and trip level	Official letter before survey	20,9% (HH level)
Germany	2008 MOP	Phone survey Random Route Dialling (RDD)	Mailed the 7-day paper and pencil diary	First contact by phone	
Italy	2000-09	Telephone interview	CATI		67%
Luxembourg	1995	Self administered by mail	No	Official letter before survey	61%
Netherlands	2004-09	Self administered + phone call motivation/ reminder (when telephone number is available)		Official letter before survey	Around 70%
	2010-..	Mixed-mode: first web-based. Persons who are not able to enter the survey by internet are reproached by telephone (when telephone number is available) or face-to-face	Yes	Official letter before survey	60% expected

Appendix A: Survey method of NTS in European Countries (suite)

Country	Year	Survey mode	Computer-aided interview	Contact before survey	Response rate individuals having described their mobility / individuals in the scope
Spain	2000	Daily mobility and household characteristics: face to face survey Long distance: telephone survey	Daily mobility: CAPI Long distance: CATI	Official letter before survey	70%
	2006	Daily mobility and household characteristics: face to face survey Long distance: telephone survey	Daily mobility: No? Long distance: CATI	Official letter before survey	55%
Sweden	2005	Telephone survey	CATI	Official letter before survey	68%
	2011-2012	Telephone survey	CATI	Official letter before survey	
Great Britain	2009	Face-to-face, 2 visits, self-completion diary	CAPI	Official letter before survey	59%
	2010	Face-to-face, 2 visits, self-completion diary	CAPI	Official letter before survey	60%
Israel	1996/97	Home interview and travel diary for completion by survey respondents	no	Official letter before survey	90% (60% full response + 30% partial response)
	2011	Daily mobility: home interview and activity-travel diary, Long-distance trips: Telephone survey	Yes. Portable computer for home interview, Internet-based travel diary, GPS for trip data	Official letter before survey, survey promotion on the radio and in the newspapers	60%

Appendix A: Survey method of NTS in European Countries (suite)

Country	Year	Survey mode	Computer-aided interview	Contact before survey	Response rate individuals having described their mobility / individuals in the scope
Norway	2005	Telephone	Yes	Letter and telephone	50%
	2009/10	Telephone	Yes	Letter and telephone	46%
Switzerland	2005	Telephone survey	Yes	Official letter before survey	72%
	2010	Telephone survey	Yes	Official letter before survey	

Appendix B: Statistical Unit of NTS in European Countries

Country	Year	Statistical unit	All household members?
Belgium	2009	Household	All household members
Denmark	From 2006	Person	1 individual
Finland	2010-11	Individual	Sampled individual
France	2007-08	Household	1 individual
Germany (MiD)	2002, 2008	Individuals aged 14 years and older	All household members (from 0 upwards)
Italy	2000-09	Persons	1 individual
Netherlands	2010-..	Persons	1 individual, who also has to fill in questions about characteristics of his/her household
Spain	2006	Household	Individual
Sweden	2011-2012	Individual	Only selected individual
Great Britain	2009	Household	All household members
Israel	2011	Household	All household members age 8 and above that spend at least three nights in the apartment
Norway	2009/10	Individuals of 13 years old and more	Only sampled individuals
Switzerland	2010	Household	Selected individual(s)

Appendix C: Sampling in NTS in European Countries

Country	Year	Sampling base	Sampling method
Austria	1995	Selected municipalities, Austrian resident	Every 20th address of a household, starting at a randomly drawn address.
Belgium	1999	National register of individuals	Random sampling with geographical, household structure stratification
	2009	National Register	Random sampling with geographical, household structure stratification
Denmark	Before 2004	National population register	Random sampling
	From 2006	National population register	Random sampling with stratification
Finland	2004-05	National population register	Random sampling with stratification (county, gender, age)
	2010-11	National population register	Random sampling with stratification (municipality group, gender, age)
France	1993-94	Census + new dwelling	Random sampling with car ownership and geographical stratification
	2007-08	Census + new dwelling	Random sampling with car ownership and geographical stratification
Germany	2002	RDD (Random Digital Dialling) for MOP Official register of inhabitants for MID	Random sampling with stratification
	2008	RDD (Random Digital Dialling) for MOP Official register of inhabitants for MID	Random sampling with stratification
Italy	2000-09	Telephone Register	Sampling with stratification (sex, age and region)
Netherlands	2004-09	Address database	Random sampling without stratification
	2010-..	Address database	Random sampling with stratification

Appendix C: Sampling in NTS in European Countries (suite)

Country	Year	Sampling base	Sampling method
Spain	2000	Municipal Population Census	Random sampling with geographical, household structure stratification
	2006	Municipal Population Census	Random sampling with geographical, household structure stratification
Sweden	2005	National population register	Random sampling with geographical stratification at region level
	2011-2012	National population register	Random sampling with geographical stratification at region level
Great Britain	1985/86	Postcode address file	Random sampling with stratification
	1988-2008	Postcode address file	Random sampling with stratification
Israel	1996/97	Addresses from city taxes files	Random sampling with geographical and socio-demographic stratification
	2011	Addresses from city taxes files	Random sampling with geographical and socio-demographic stratification
Norway	2005	National population register	Random sampling
	2009/10	National population register	Random sampling
Switzerland	2005	Census	Random sampling with geographical and socio-demographic stratification
	2010	Census	Random sampling with geographical and socio-demographic stratification

Appendix D: The Data Needs questionnaire

Thank you for taking the time to answer to this questionnaire! Your contribution as a member of the travel surveys community is highly appreciated. We are a team of researchers working in the European COST Action SHANTI. It aims at data harmonization of National Travel Surveys. As part of the SHANTI action, we are interested in knowing your opinions on which information gathered through a typical national travel survey is more important for you, considering the usage of such data that you experience or envisage.

Section A: About SHANTI and YOU

A1. Which of the following items better describes your actual position (pick one)?

- ❑ I am working in a university or a research institute.
- ❑ I am working in a policy-oriented public body (Ministry, national, regional or local transport department, mobility agency...).
- ❑ I am working in a European or international organisation.
- ❑ I am working in a transport-related industry (transport services operator, infrastructures manager...).
- ❑ I am working in a consultancy firm or I am a consultant.
- ❑ Other

A2. The SHANTI project is almost finished. Did you attend any of the past SHANTI meetings or are you planning to attend one of the remaining meetings in the near Future?

- ❑ Yes
- ❑ No

A3. In which continent is the agency/institution you are working for based?

- ❑ Africa Skip to 5
- ❑ Asia Skip to 5
- ❑ Australia Skip to 5
- ❑ Europe
- ❑ North America Skip to 5
- ❑ South America Skip to 5

A4. In which country is the agency or institution you are working for located?

List of European countries

A5. Has your agency or institution ever been involved in the implementation of a national travel survey?

- ❑ Yes
- ❑ No

A6. For which of the following tasks was your agency or institution responsible? (Multiple answers are possible)

- ❑ Designing the survey
- ❑ Field work (survey administration, delivery of the survey material,...)
- ❑ Analysis

A7. For you what is your current usage of household travel surveys? (Multiple answers are possible)

- ❑ Estimation of patterns of demand
- ❑ Estimation of need
- ❑ Estimation of travel impacts
- ❑ Market research
- ❑ Analysis of impacts and behaviour to deduce causation

Section B: The "Household" section of the travel survey questionnaire (1)

B1. We would like you to evaluate the importance of the following questionnaire items: Indicate for each questionnaire item whether it should be considered 1) essential (it should be part of every national travel survey no matter what) 2) recommended (the item is recommended for methodological/analytical issues (e.g. weighting)) 3) secondary (not essential and not (absolutely) required for methodological/analytical issues) Please disregard the fact that some items do not need to be directly asked for, since they could be available.

** Note: In certain national travel survey several of these person-based questions are asked in the person questionnaire, in other national travel survey in the household questionnaire. Please evaluate the necessity of the question, not the fact whether it should be part of the household questionnaire or of the person-based questionnaire.*

	Essential	**Recommended**	**Secondary**	**No opinion**
Date of the survey (YYYY/MM/DD)	□	□	□	□
Dwelling/housing type (e.g. detached / semi-detached /...)	□	□	□	□
Dwelling/housing ownership (e.g. owner / tenant /...)	□	□	□	□
Landline telephone availability (Yes / No)	□	□	□	□
Internet connection (Yes / No)	□	□	□	□
Net household income (using predefined income categories)	□	□	□	□
Number of persons (within the household)	□	□	□	□
Gender of the person	□	□	□	□
Age of the person / Date of birth of the person	□	□	□	□
Occupation status (active / non-active)	□	□	□	□
Type of occupation (e.g. blue vs. white-collar worker)	□	□	□	□
Type of non-activity (e.g. retired, student,...)	□	□	□	□
Work regime (full-time, part-time,...)	□	□	□	□
Educational background	□	□	□	□

B2. For which household members should the basic information be collected? (This question is especially relevant, when only one person within the household is surveyed)

- *All household members (all adults and all children)* **Skip to 9**
- *Adults only* **Skip to 9**
- *All adults, and a selection of the children*
- *A selection of adults or children* **Skip to 9**
- *No opinion* **Skip to 9**

B3. Please enter here the maximum number of children for which information should be collected:

Section C: The "Household" section of the travel survey questionnaire (2)

C1. We would like you to evaluate the importance of the following questionnaire items: Indicate for each questionnaire item whether it should be considered 1) essential (it should be part of every national travel survey no matter what) 2) recommended (the item is recommended for methodological/analytical issues (e.g. weighting)) 3) secondary (not essential and not (absolutely) required for methodological/analytical issues) Please disregard the fact that some items do not need to be directly asked for, since they could be available.

	Essential	Recommended	Secondary	No opinion
Number of bicycles (within the household)	□	□	□	□
Number of mopeds/motorcycles (within the household)	□	□	□	□
Brand of the moped/motorcycle	□	□	□	□
Type/model of the moped/ motorcycle	□	□	□	□
Cylinder capacity of the engine of the moped/motorcycle	□	□	□	□
Power of the engine of the moped/motorcycle	□	□	□	□
Year of purchase of the moped/ motorcycle	□	□	□	□
Year of construction of the moped/motorcycle	□	□	□	□
Mileage last 12 months of the moped/motorcycle	□	□	□	□
Total mileage of the moped/ motorcycle	□	□	□	□

C2. Of how many mopeds/motorcycles should additional information be queried?

- *Maximum 1*
- *Maximum 2*
- *Maximum 3*
- *>3, but not all*
- *All mopeds/motorcycles within the household*
- *No opinion*

Section D: The "Household" section of the travel survey questionnaire (3)

D1. We would like you to evaluate the importance of the following questionnaire items: Indicate for each questionnaire item whether it should be considered 1) essential (it should be part of every national travel survey no matter what) 2) recommended (the item is recommended for methodological/analytical issues (e.g. weighting)) 3) secondary (not essential and not (absolutely) required for methodological/analytical issues) Please disregard the fact that some items do not need to be directly asked for, since they could be available.

	Essential	Recommended	Secondary	No opinion
Type/model of the car (e.g. Micra)	□	□	□	□
Number of cars (within the household)	□	□	□	□
Brand of the car (e.g. Nissan)	□	□	□	□
Category of car (e.g. car, delivery van, camper, other)	□	□	□	□
Energy source of the car	□	□	□	□
Cylinder capacity of the engine of the car	□	□	□	□
Power of the engine of the car	□	□	□	□
Fiscal/taxable power of the engine of the car	□	□	□	□
Year of purchase of the car	□	□	□	□
Method of acquisition of the car (e.g. new/2nd hand/company)	□	□	□	□
Availability of the car (fully available/partially available)	□	□	□	□
Year of construction of the car	□	□	□	□
Total mileage for the last 12 months of the car	□	□	□	□
Options for parking the car during the night (e.g. in the street)	□	□	□	□
Costs for parking the car during the night (e.g. free)	□	□	□	□

D2. Of how many cars should additional information be queried?

- *Maximum 1*
- *Maximum 2*
- *Maximum 3*

- *>3, but not all*
- *All cars within the household*
- *No opinion*

D3. Please explain below if and how the power system and the energy source of the car should be queried.

Section E: Individual questionnaire (1)

E1. We would like you to evaluate the importance of the following questionnaire items: Indicate for each questionnaire item whether it should be considered 1) essential (it should be part of every national travel survey no matter what) 2) recommended (the item is recommended for methodological/analytical issues (e.g. weighting)) 3) secondary (not essential and not (absolutely) required for methodological/analytical issues) Please disregard the fact that some items do not need to be directly asked for, since they could be available.

	Essential	Recommended	Secondary	No opinion
Gender	□	□	□	□
Age / Date of birth of the person	□	□	□	□
Relation to the reference person (Spouse, child,...)	□	□	□	□
Mobile phone owned for personal use (Yes/No)	□	□	□	□
Mobile phone owned for professional use (Yes/No)	□	□	□	□
Personal email consulted at least once a week (Yes/No)	□	□	□	□
Professional email consulted at least once a week (Yes/No)	□	□	□	□
Driving license for private vehicles (Yes/No)	□	□	□	□
Number of years holding a driving license for private vehicles	□	□	□	□
Educational background	□	□	□	□
Main occupation (e.g. blue-collar, white-collar, student,...)	□	□	□	□
Other occupation (worker/ student/not applicable)	□	□	□	□
Additional information for workers	□	□	□	□

Number of working hours per week	□	□	□	□
Work regime (night, day, shifts,...)	□	□	□	□
Work flexibility (fixed hours, flexible hours)	□	□	□	□
Possession of a public transport card (season ticket or transit pass)	□	□	□	□

Section F: Individual questionnaire (2)

F1. We would like you to evaluate the importance of the following questionnaire items: Indicate for each questionnaire item whether it should be considered 1) essential (it should be part of every national travel survey no matter what) 2) recommended (the item is recommended for methodological/analytical issues (e.g. weighting)) 3) secondary (not essential and not (absolutely) required for methodological/analytical issues) Please disregard the fact that some items do not need to be directly asked for, since they could be available.

** Note: 1) Please note that the focus is on the level of detail that is required for the data use that you experience or envisage, not on the level of detail in which the information will be made publicly available. 2) NUTS: http://en.wikipedia.org/wiki/Nomenclature_of_Territorial_Units_for_Statistics 3) LAU: http://en.wikipedia.org/wiki/Category:LAU_1_statistical_regions_of_the_European_Union*

	Essential	**Recommended**	**Second-ary**	**No opinion**
Domicile for the travel day: at home / not at home	□	□	□	□
Domicile for the travel day: geographical information	□	□	□	□
NUTS 2 of the address*	□	□	□	□
NUTS 3 of the address*	□	□	□	□
LAU 1 (NUTS 4) of the address*	□	□	□	□
LAU 2 (NUTS 5) of the address*	□	□	□	□
Street of the address*	□	□	□	□
Full address*	□	□	□	□
Domicile for the travel day: parking possibilities	□	□	□	□
Domicile for the travel day: parking costs (e.g. free)	□	□	□	□

F2. We would like you to evaluate the importance of the following questionnaire items: Indicate for each questionnaire item whether it should be considered 1) essential (it should be part of every national travel survey no matter what) 2) recommended (the item is recommended for methodological/analytical issues (e.g. weighting)) 3) secondary (not essential and not (absolutely) required for methodological/analytical issues) Please disregard the fact that some items do not need to be directly asked for, since they could be available.

** Note: his question queries the required level of detail, it does not query the level of detail in which the information will be made publicly available.*

	Essential	Recommended	Secondary	No opinion
Domicile for the travel day: at home / not at home	□	□	□	□
Domicile for the travel day: geographical information	□	□	□	□
Street of the address*	□	□	□	□
Full address*	□	□	□	□
Domicile for the travel day: parking possibilities	□	□	□	□
Domicile for the travel day: parking costs (e.g. free)	□	□	□	□

Section G: Person questionnaire (3)

G1. We would like you to evaluate the importance of the following questionnaire items: Indicate for each questionnaire item whether it should be considered 1) essential (it should be part of every national travel survey no matter what) 2) recommended (the item is recommended for methodological/analytical issues (e.g. weighting)) 3) secondary (not essential and not (absolutely) required for methodological/analytical issues) Please disregard the fact that some items do not need to be directly asked for, since they could be available.

	Essential	Recommended	Secondary	No opinion
(Average) Frequency of travelling by foot	□	□	□	□
(Average) Frequency of travelling by bike	□	□	□	□
(Average) Frequency of travelling by moped/motorcycle	□	□	□	□
(Average) Frequency of travelling by bus	□	□	□	□

(Average) Frequency of travelling by tram	□	□	□	□
(Average) Frequency of travelling by train	□	□	□	□
(Average) Frequency of travelling by taxi	□	□	□	□
(Average) Frequency of travelling by car (as driver)	□	□	□	□
(Average) Frequency of travelling by car (as passenger)	□	□	□	□

G2. The above (average) frequencies should be queried as:

- ❑ A numerical value indicating how many trips on average are made during a certain time period (e.g. per week)
- ❑ An Ordered categorical value (e.g. almost always, a few days per week, a few days per month, a few days per year, never)

G3. The above (average) frequencies should be queried for

- ❑ Weekdays (Monday until Friday) only
- ❑ All seven days

Section H: Trip questionnaire (1)

In the following, we adopt these definitions: A stage is a continuous movement with one mode of transport and a single vehicle. A trip is a continuous sequence of stages and it takes place between two activities.

H1. The respondent should report information about the trips s/he made during the day...

- ❑ From 0:00 until 23:59
- ❑ From 1:00 until 00:59
- ❑ From 2:00 until 01:59
- ❑ From 3:00 until 02:59
- ❑ From 4:00 until 03:59
- ❑ From 5:00 until 04:59
- ❑ From 6:00 until 05:59
- ❑ No opinion

H2. A trip must have the following minimal distance to be reported:

- ❑ 0 m (all trips should be reported, no matter what distance)
- ❑ 50 m
- ❑ 100 m

- ❑ 200 m
- ❑ No opinion

H3. Concerning the geographical information about the trips, the minimum level of detail in terms of statistical subdivision of the country should be: (the focus is on the level of detail that is required for the data use that you experience or envisage, not on the level of detail in which the information will be made publicly available).

- ❑ NUTS 2 of the address
- ❑ NUTS 3 of the address
- ❑ LAU 1 (NUTS 4) of the address
- ❑ LAU 2 (NUTS 5) of the address
- ❑ Street of the address
- ❑ Full address
- ❑ No opinion

H4. Always concerning the geographical information about the trips, the minimum level of detail in terms of administrative subdivisions should be: (the focus is on the level of detail that is required for the data use that you experience or envisage, not on the level of detail in which the information will be made publicly available).

- ❑ Full address
- ❑ Street of the address
- ❑ Municipality
- ❑ Administrative division one level above the municipality
- ❑ Administrative division two levels above the municipality (e.g. Regions)
- ❑ No opinion

Section I: Travel questionnaire (1)

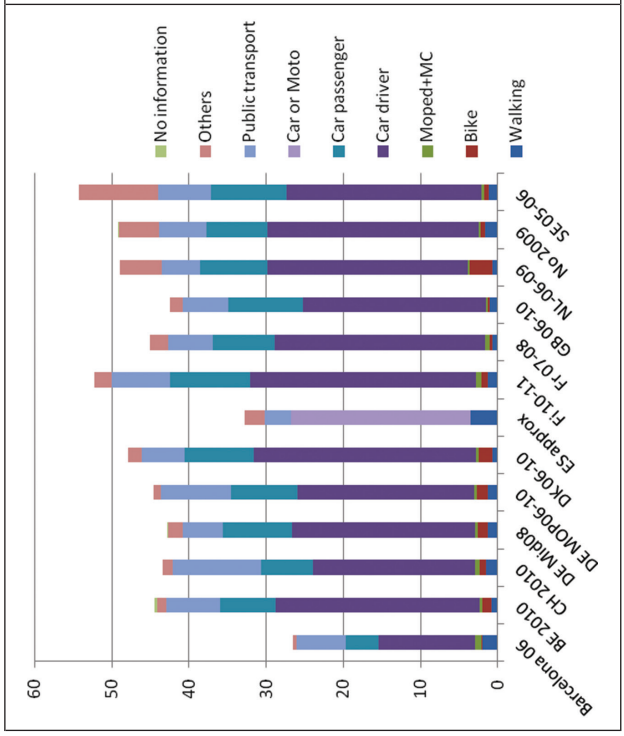
I1. We would like you to evaluate the importance of the following questionnaire items: Indicate for each questionnaire item whether it should be considered 1) essential (it should be part of every national travel survey no matter what) 2) recommended (the item is recommended for methodological/analytical issues (e.g. weighting)) 3) secondary (not essential and not (absolutely) required for methodological/analytical issues) Please disregard the fact that some items do not need to be directly asked for, since they could be available.

** Note: A stage is a continuous movement with one mode of transport and a single vehicle. It includes any pure waiting (idle) times immediately before or during that movement. A trip is a continuous sequence of stages and it takes place between two activities.*

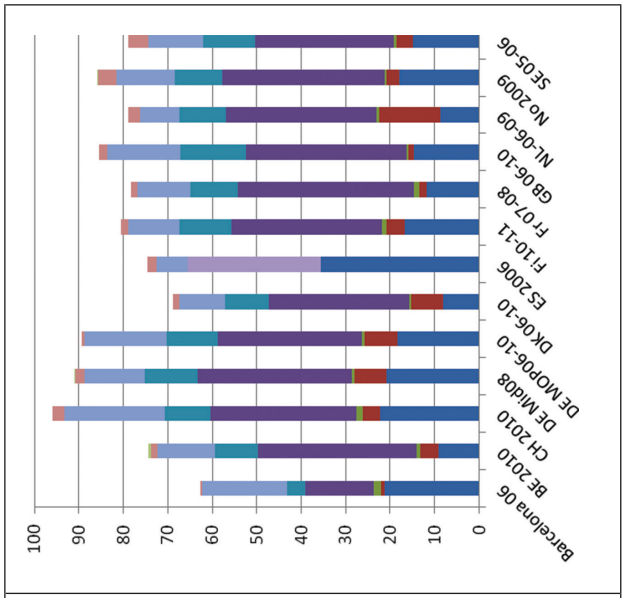
	Essential	**Recommended**	**Secondary**	**No opinion**
Trip purpose (very detailed, e.g. list of 40 purposes)	□	□	□	□
Trip purpose (generic, e.g. list of 10 purposes)	□	□	□	□
Starting point of the trip	□	□	□	□
Starting time of the trip	□	□	□	□
Destination point of the trip	□	□	□	□
Arrival time of the trip	□	□	□	□
(Self-reported) Trip distance of the trip	□	□	□	□
Main transport mode of the trip	□	□	□	□
Bearing of the costs of the trip (full, partly, none)	□	□	□	□
For each stage within the trip: starting point	□	□	□	□
For each stage within the trip: destination point	□	□	□	□
For each stage within the trip: starting time	□	□	□	□
For each stage within the trip: arrival time	□	□	□	□
For each stage within the trip: duration	□	□	□	□
For each stage within the trip: (self-reported) distance	□	□	□	□
For each stage within the trip: transport mode	□	□	□	□
For each stage by car as driver: number of occupants	□	□	□	□
For each stage by car as driver: specification of the car	□	□	□	□
For each stage by car as driver: type of parking place	□	□	□	□
For each stage by car as driver: parking costs	□	□	□	□
For each stage by car as driver: parking search time	□	□	□	□

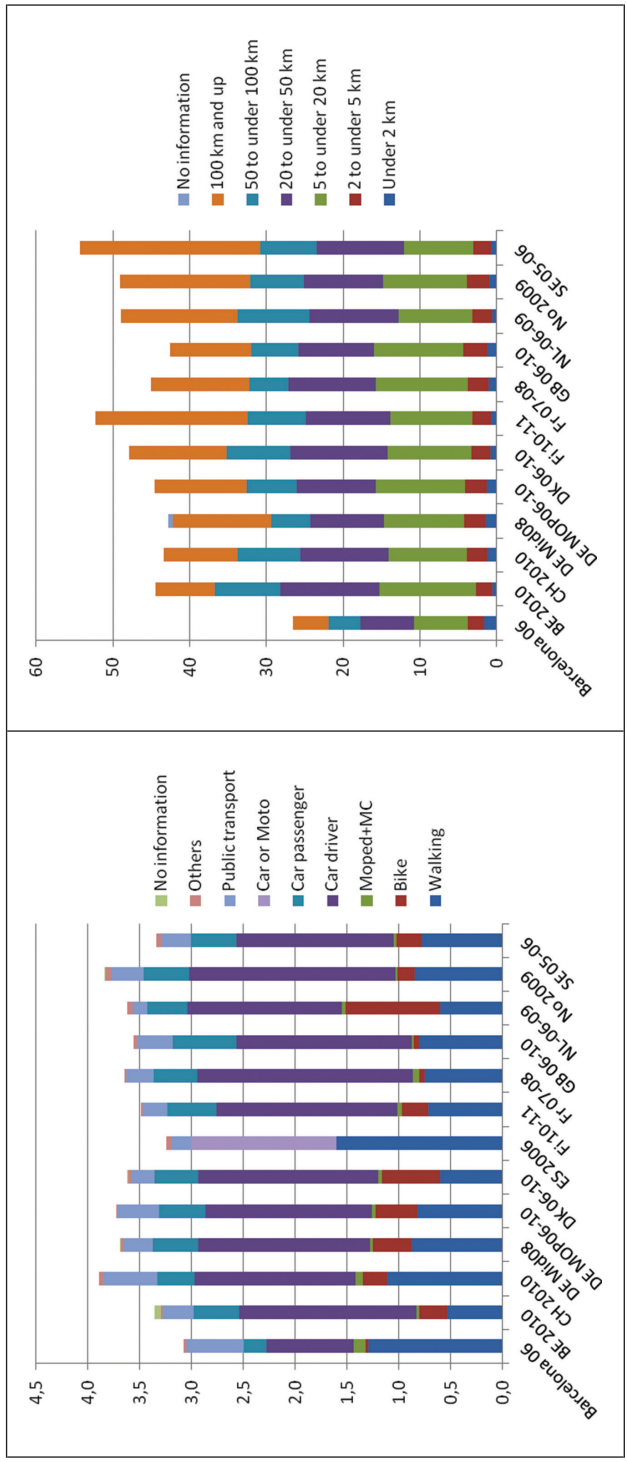
Appendix E: Figures of post-harmonisation of data from National Travel Surveys across Europe

Appendix E *Figure 1:* ***Distance travelled*** *in kilometres per traveller per day. Per mode*



Appendix E *Figure 2:* ***Time use*** *in minutes per traveller per day. Per mode*

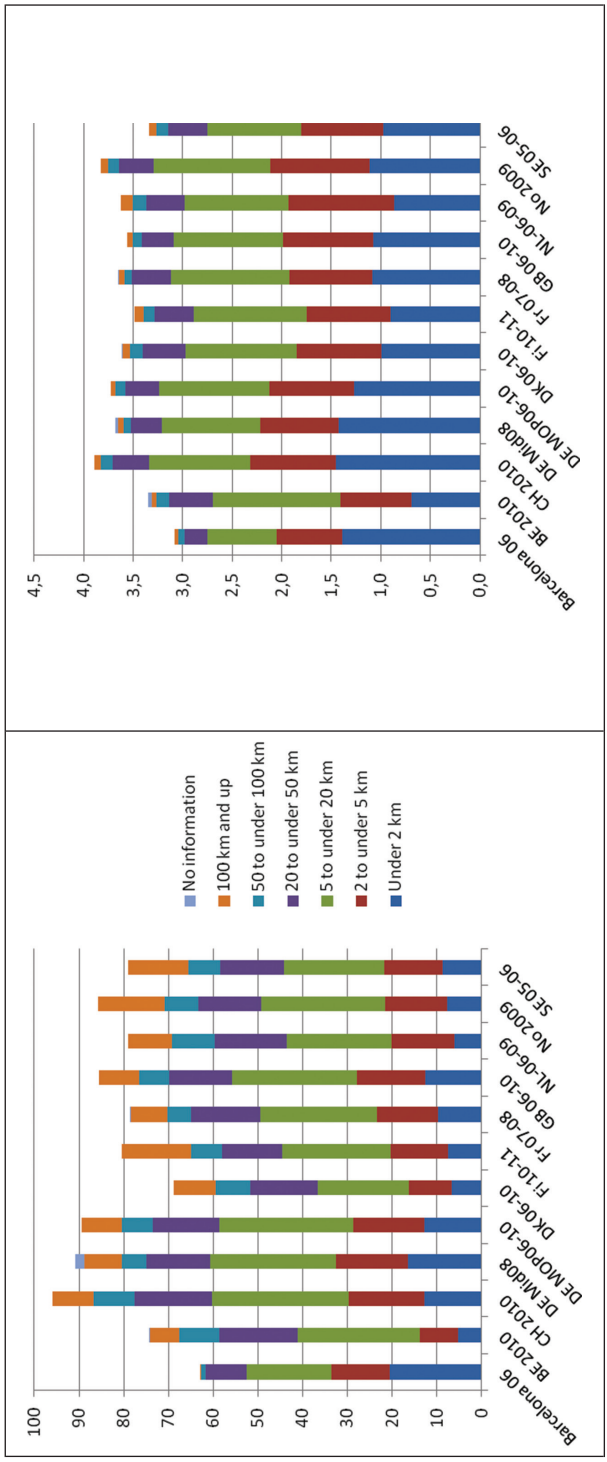




Appendix E *Figure 3:* ***Number of trips*** *per traveller per day. Per mode*

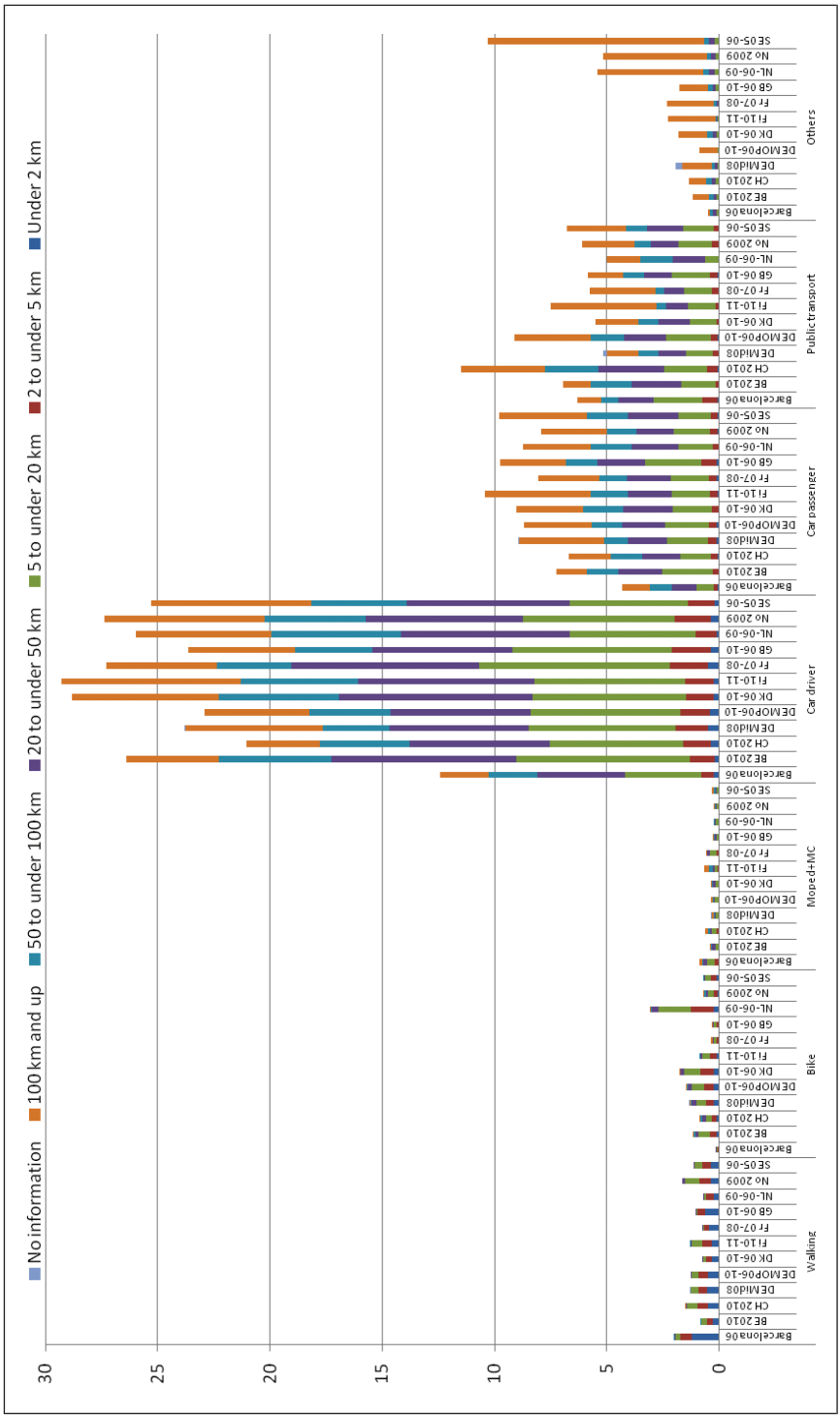
Appendix E *Figure 4:* ***Distance travelled*** *in kilometres per traveller per day. For distance bands*

Appendix E *Figure 5: **Time use** in minutes per traveller per day. For distance bands*

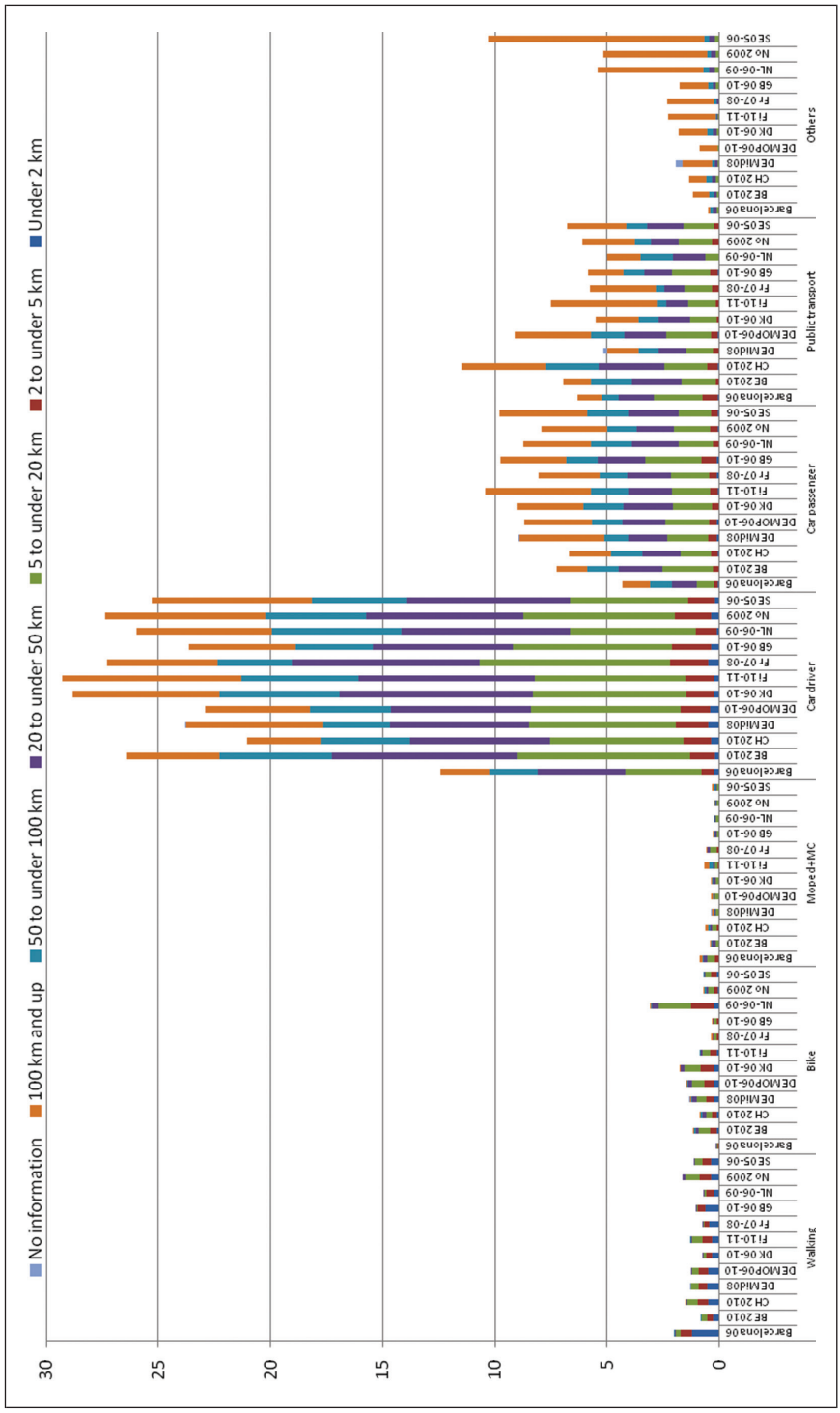


Appendix E *Figure 6: **Number of trips** per traveller per day. For distance bands*

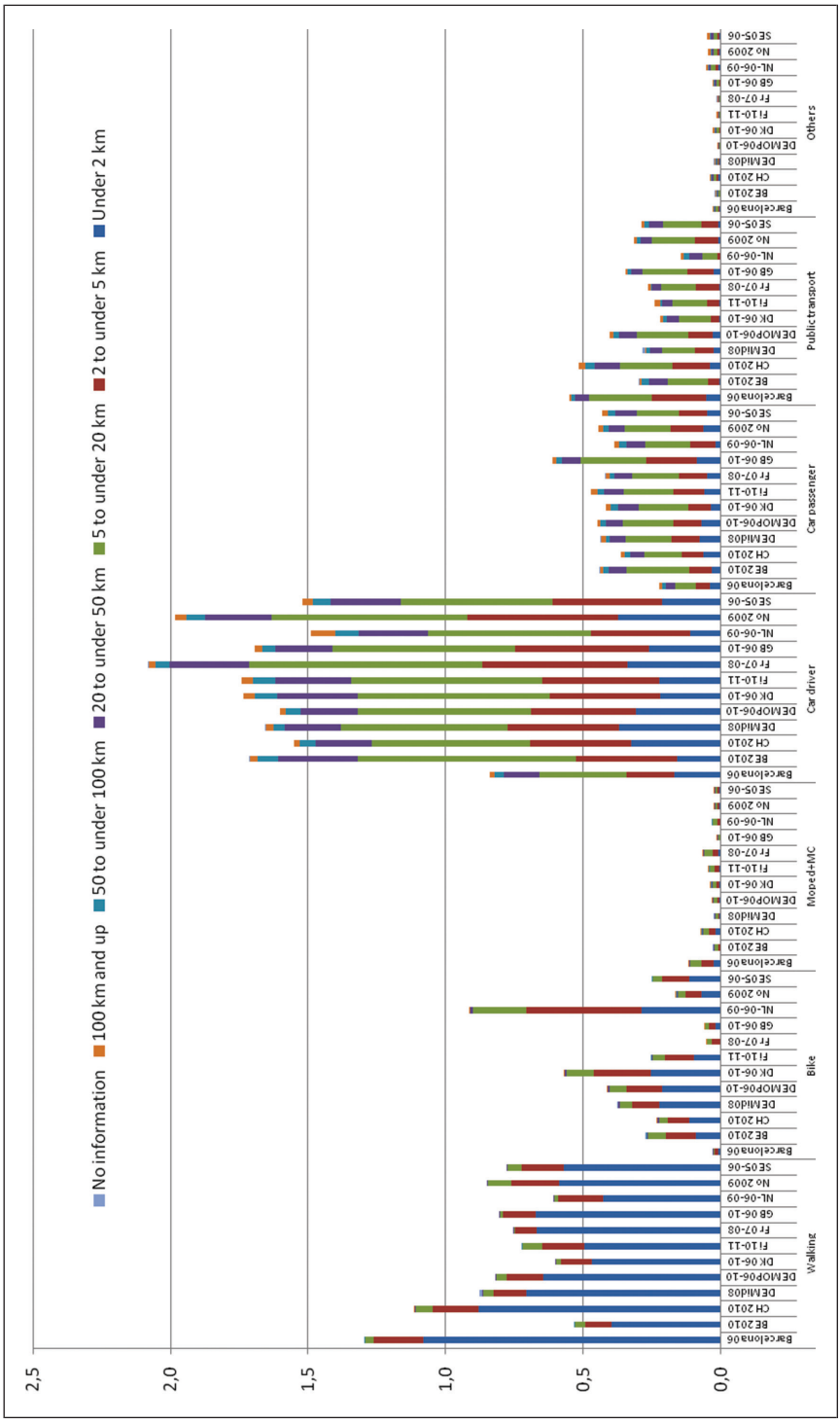
Appendix E *Figure 7:* ***Distance travelled*** *in kilometres per traveller per day. For modes and distance bands*



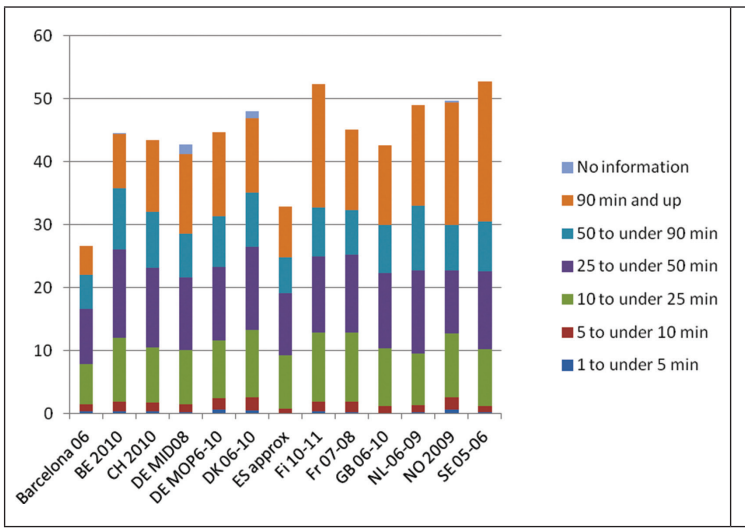
Appendix E *Figure 8:* ***Time use*** *in minutes per traveller per day. For mode and distance bands*



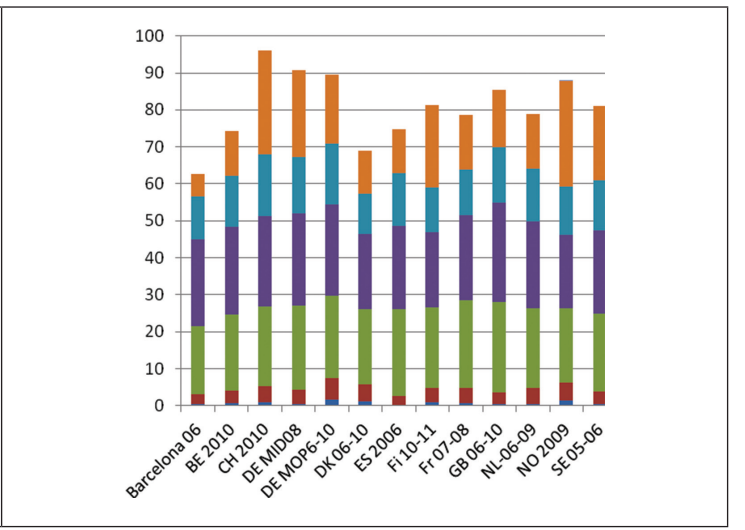
Appendix E *Figure 9:* ***Number of trips*** *per traveller per day. For modes and distance bands*



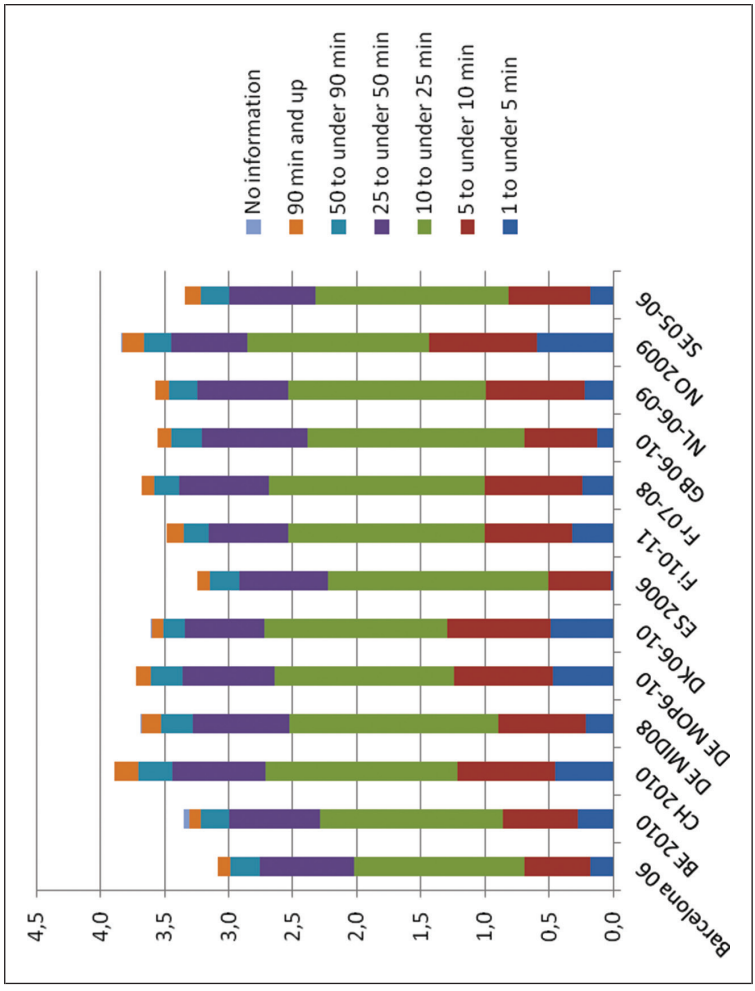
Appendix E *Figure 10:* ***Distance travelled*** *in kilometres per traveller per day. For time use bands*



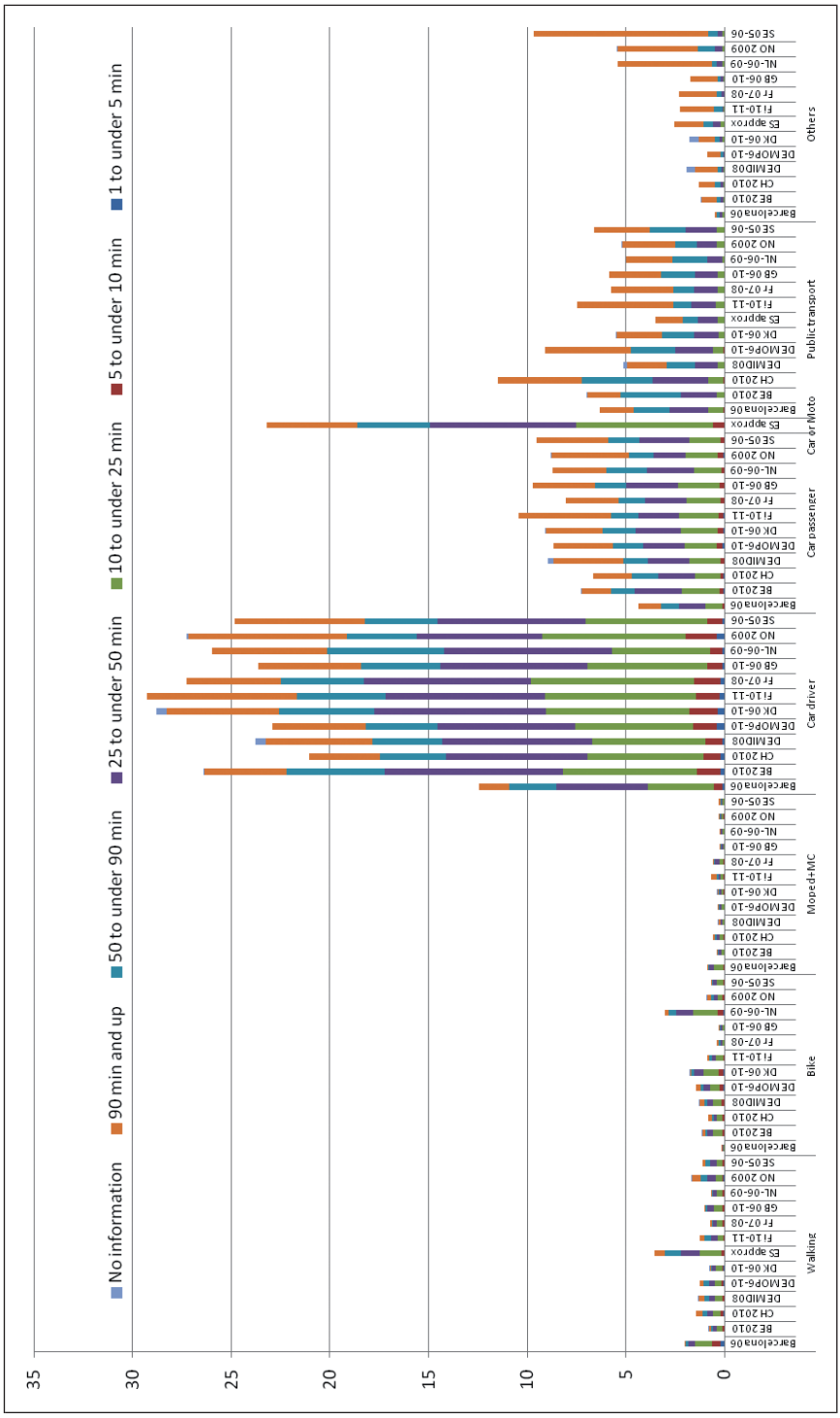
Appendix E *Figure 11:* ***Time use*** *in minutes per traveller per day. For time use bands*



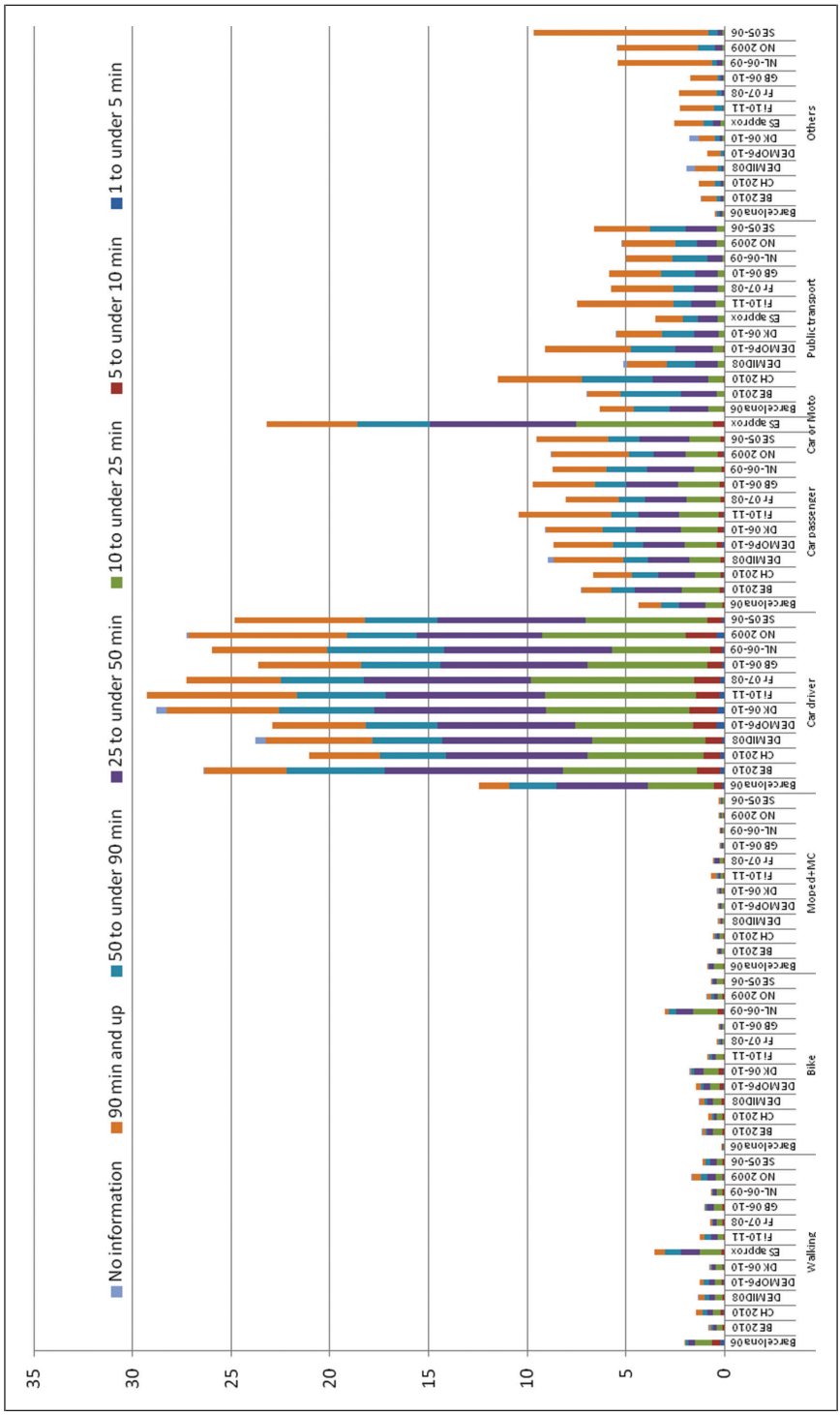
Appendix E *Figure 12:* ***Number of trips*** *per traveller per day. For time use bands*

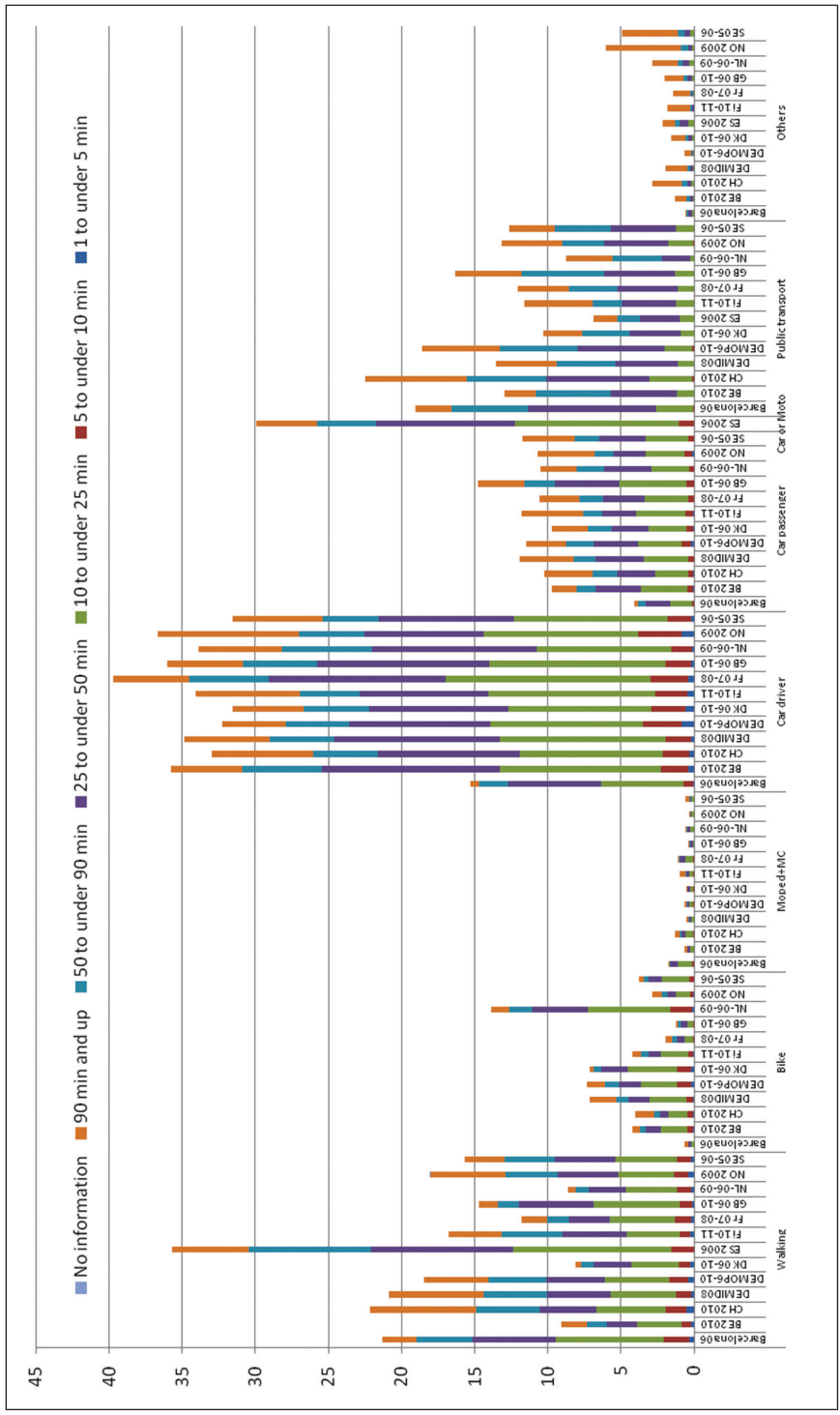


Appendix E *Figure 13: **Distance travelled** in kilometres per traveller per day. For modes and time use bands*

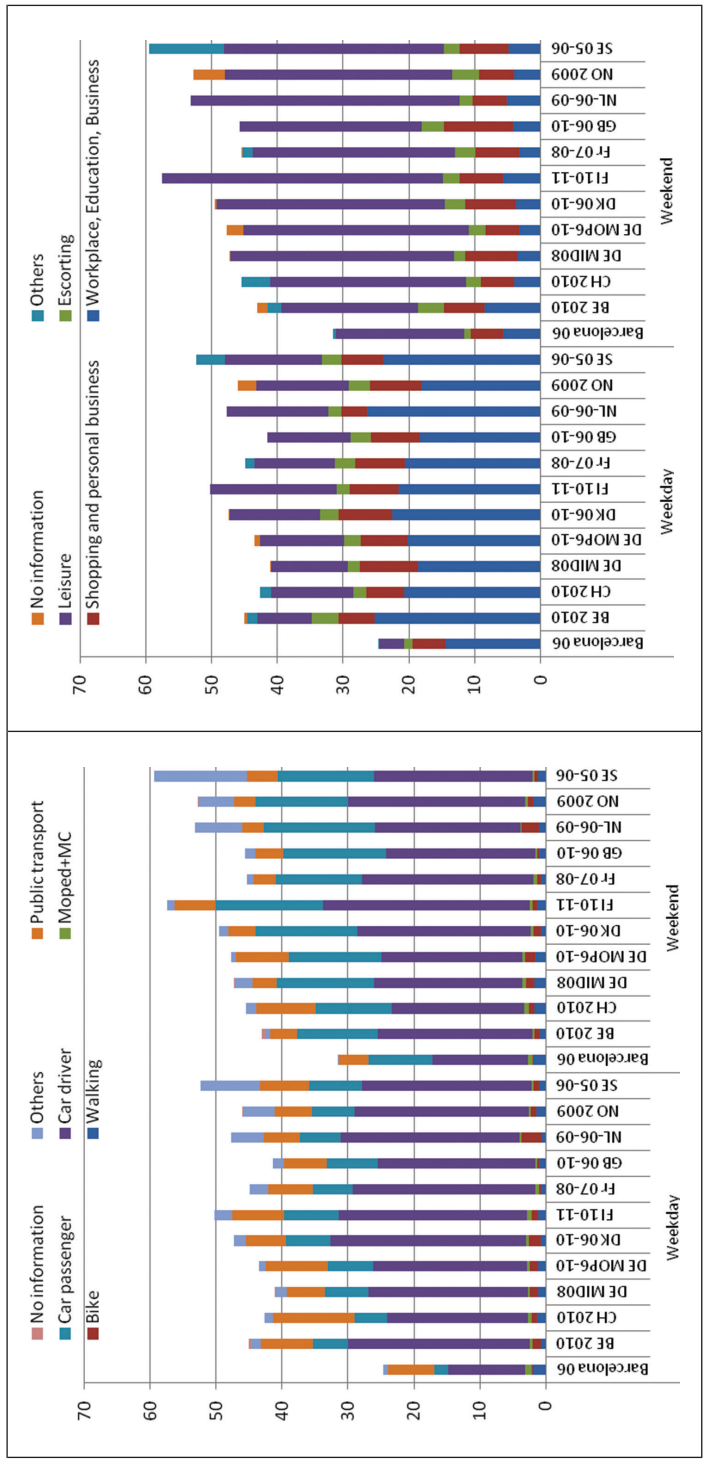


Appendix E *Figure 14:* ***Time use*** *in minutes per traveller per day. For mode and time use bands*



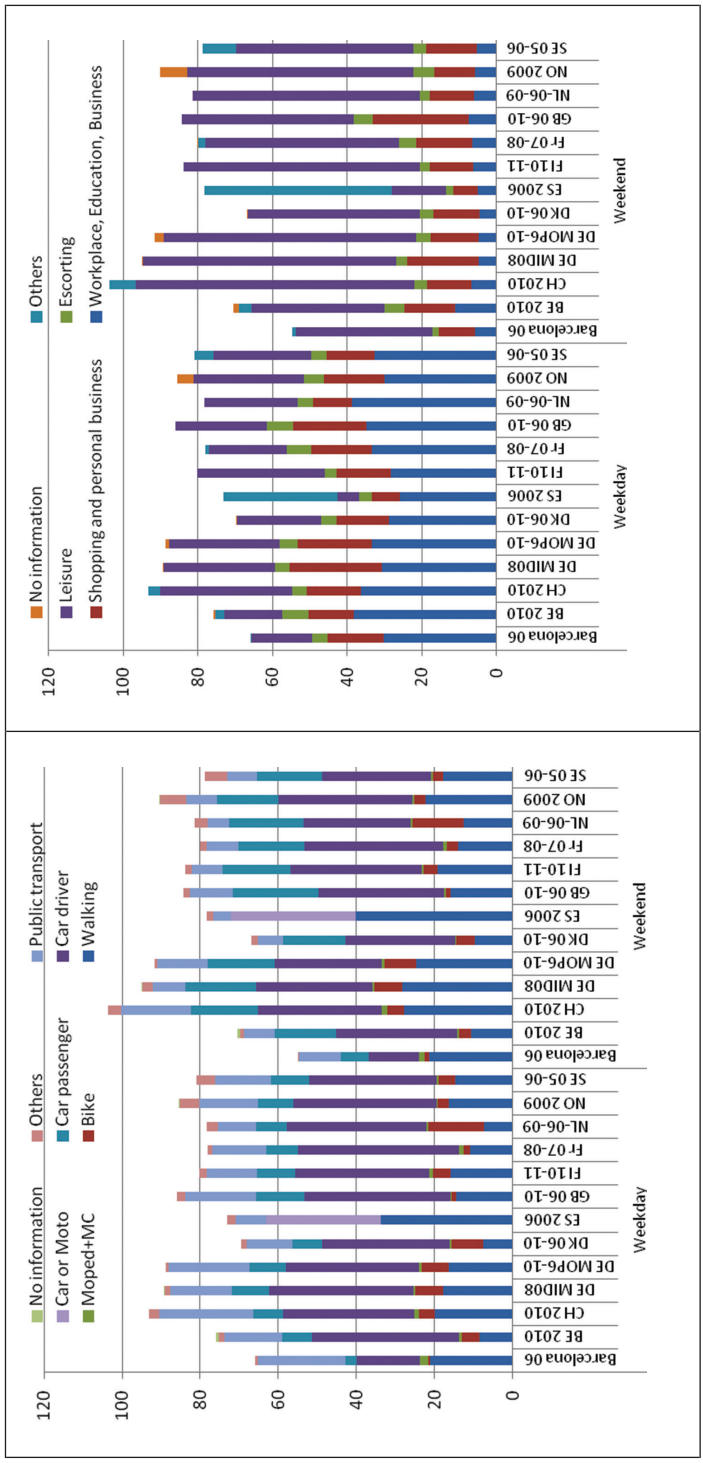


Appendix E *Figure 15:* ***Number of trips*** *per traveller per day. For modes and time use bands*



Appendix E *Figure 16: **Distance travelled** in kilometres per traveller per day. For modes and weekday / weekend*

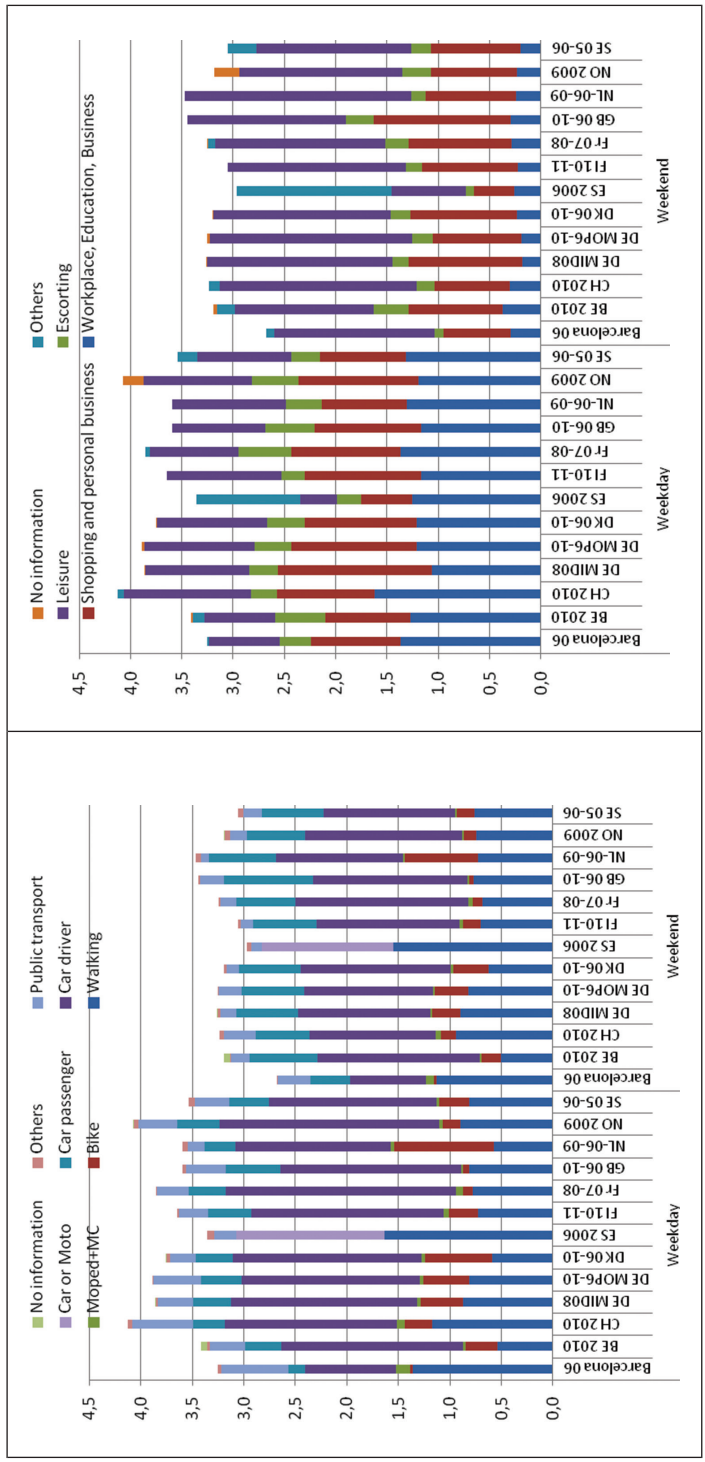
Appendix E *Figure 17: **Distance travelled** in kilometres per traveller per day. For purpose and weekday / weekend*



Appendix E *Figure 18: **Time use** in minutes per traveller per day. For modes and weekday / weekend*

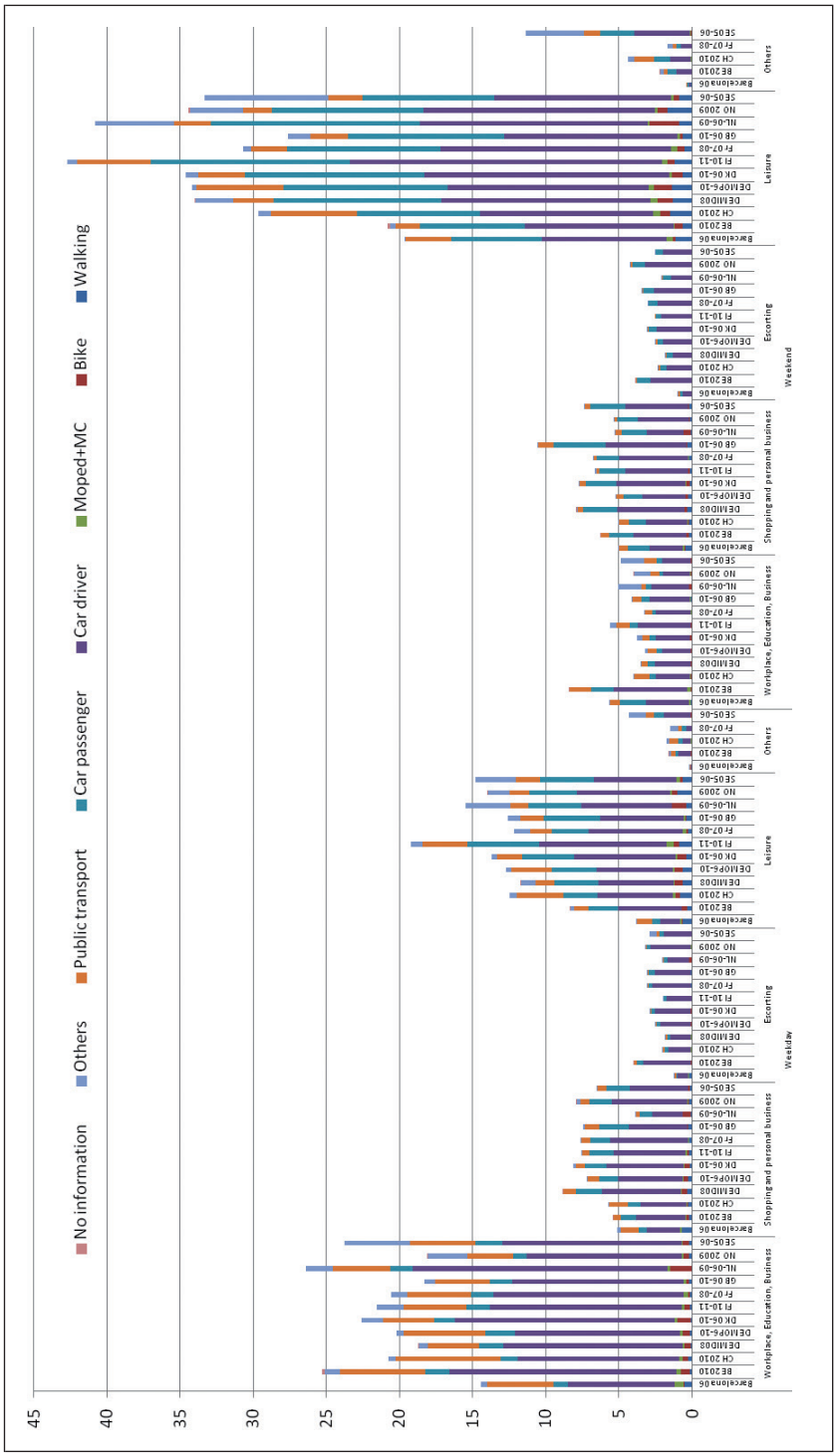
Appendix E *Figure 19: **Time use** in minutes per traveller per day. For purpose and weekday / weekend*

Appendix E *Figure 20: **Number of trips** per traveller per day. For modes and weekday / weekend*

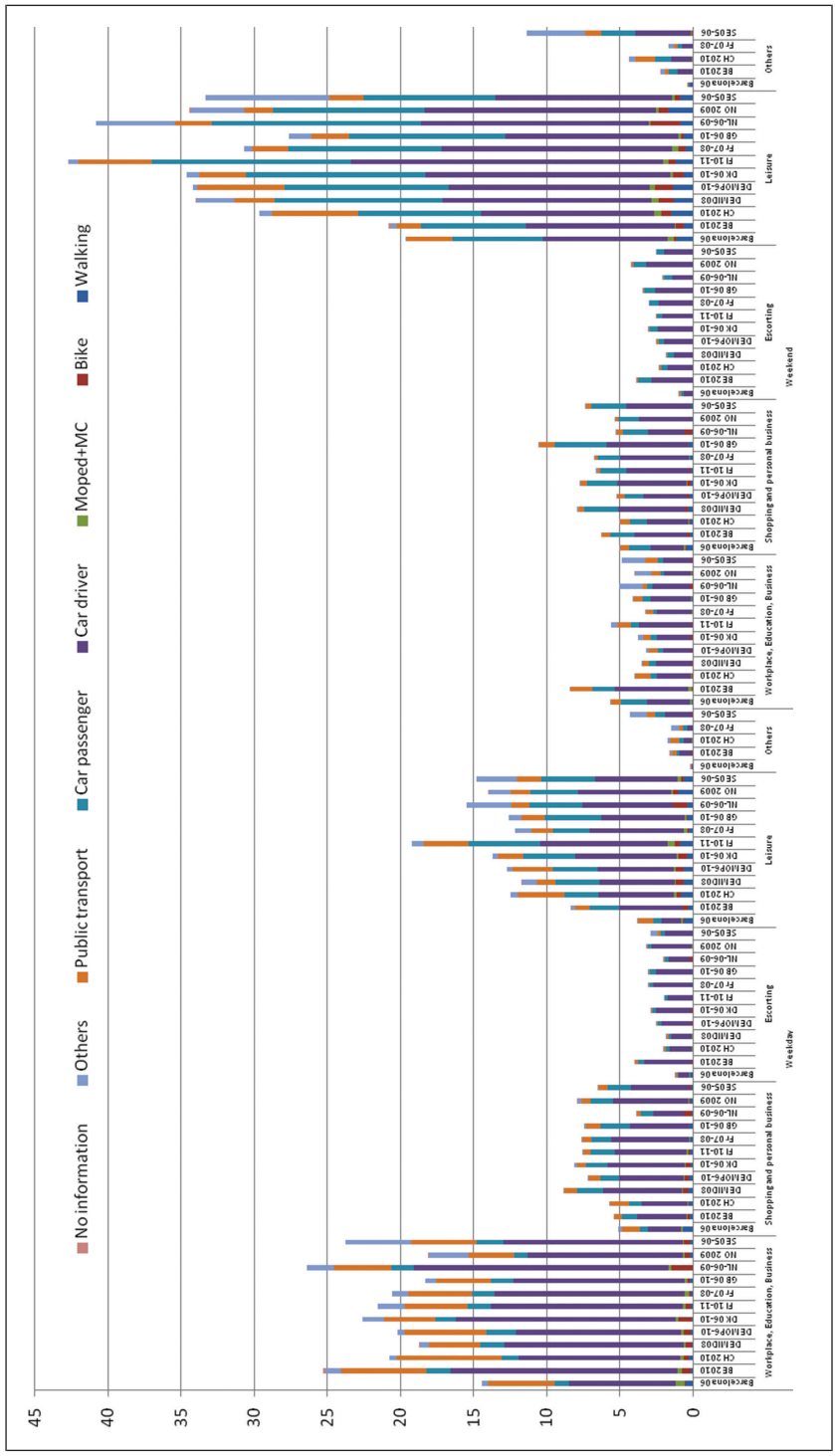


Appendix E *Figure 21: **Number of trips** per traveller per day. For purpose and weekday / weekend*

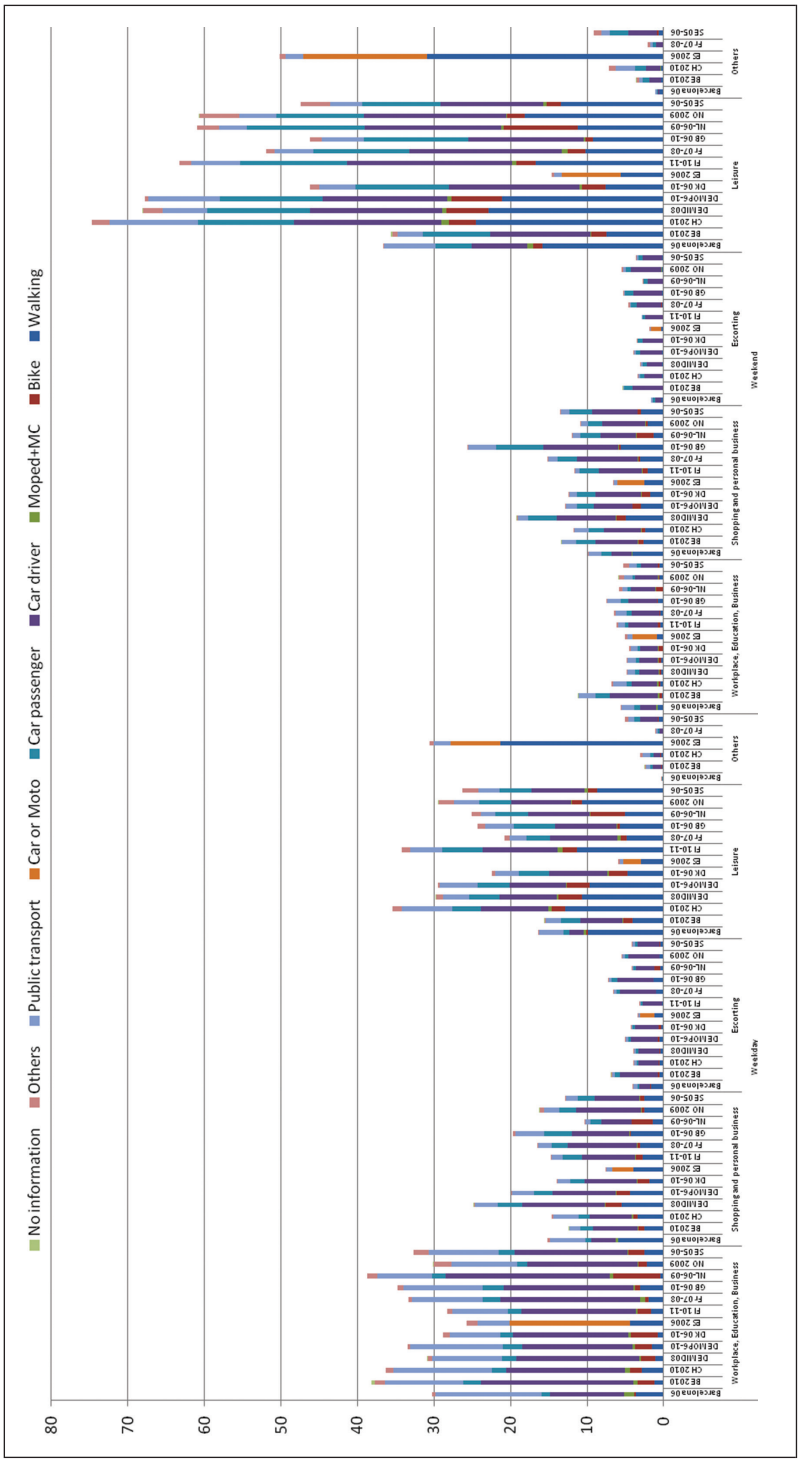
Appendix E *Figure 22:* ***Distance travelled*** *in kilometres per traveller per day. For purpose, modes, and weekday / weekend*

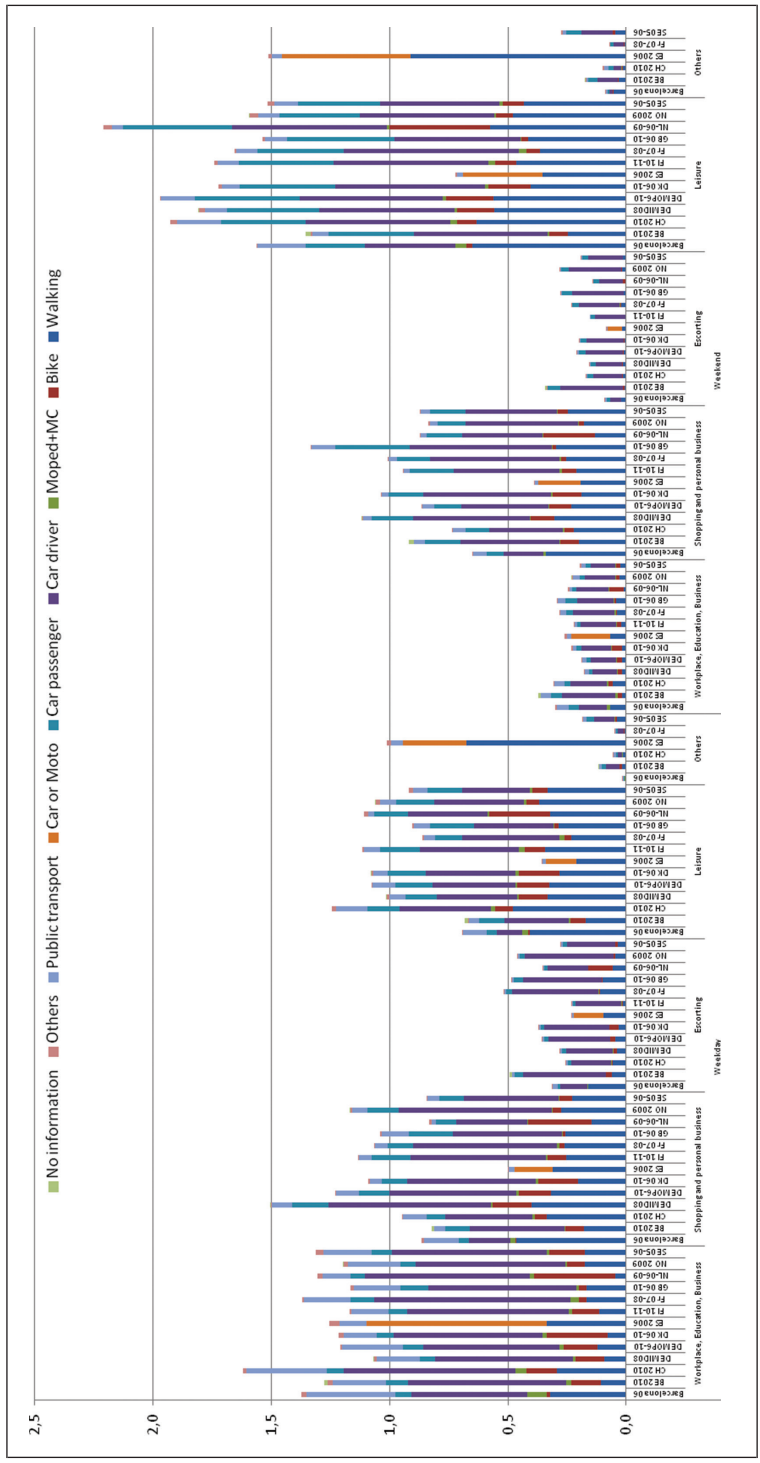


Appendix E *Figure 23:* ***Time use*** *in minutes per traveller per day. For purpose, modes, and weekday / weekend*



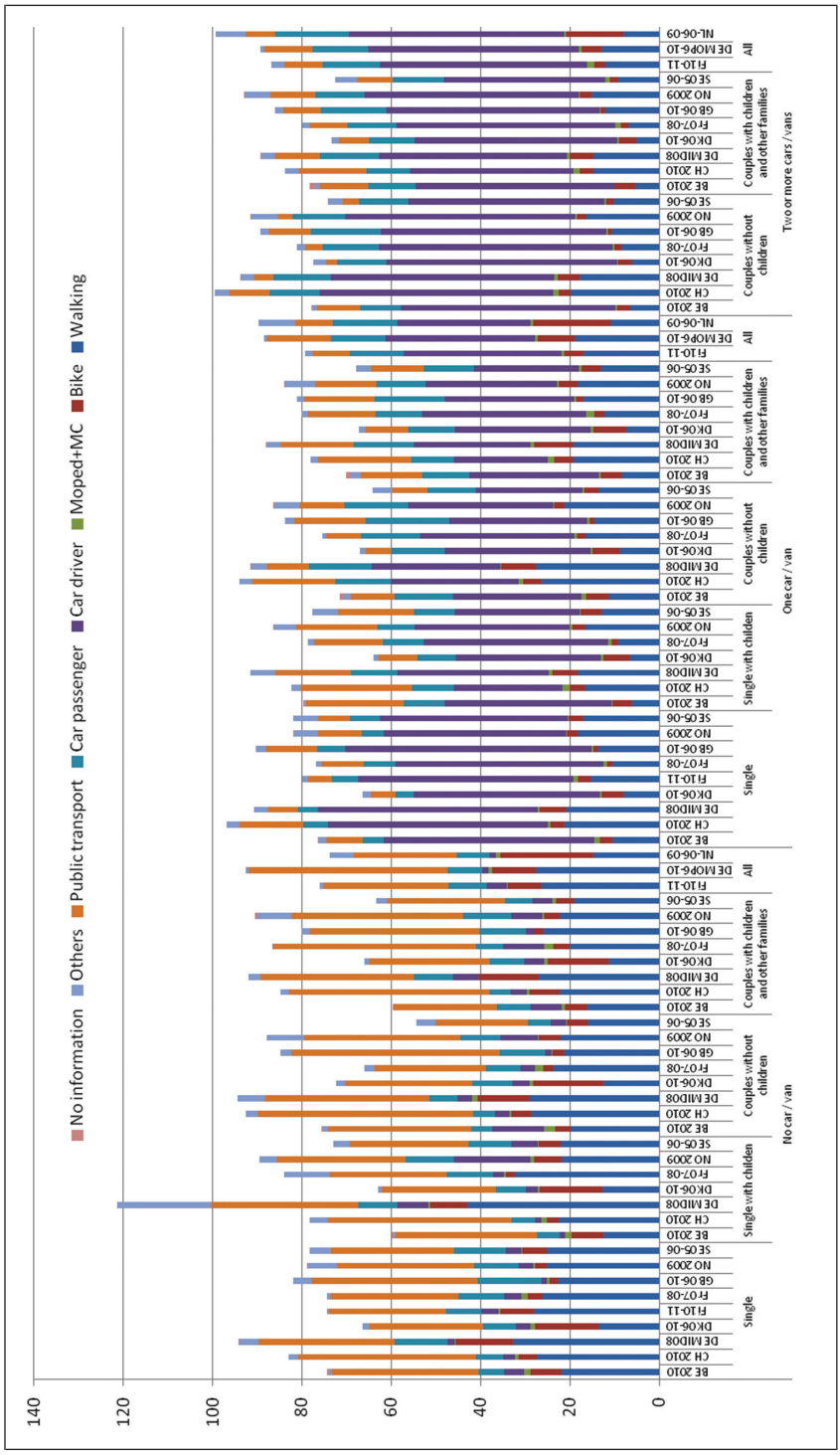
Appendix E *Figure 24:* ***Number of trips*** *per traveller per day. For purpose, modes, and weekday / weekend*



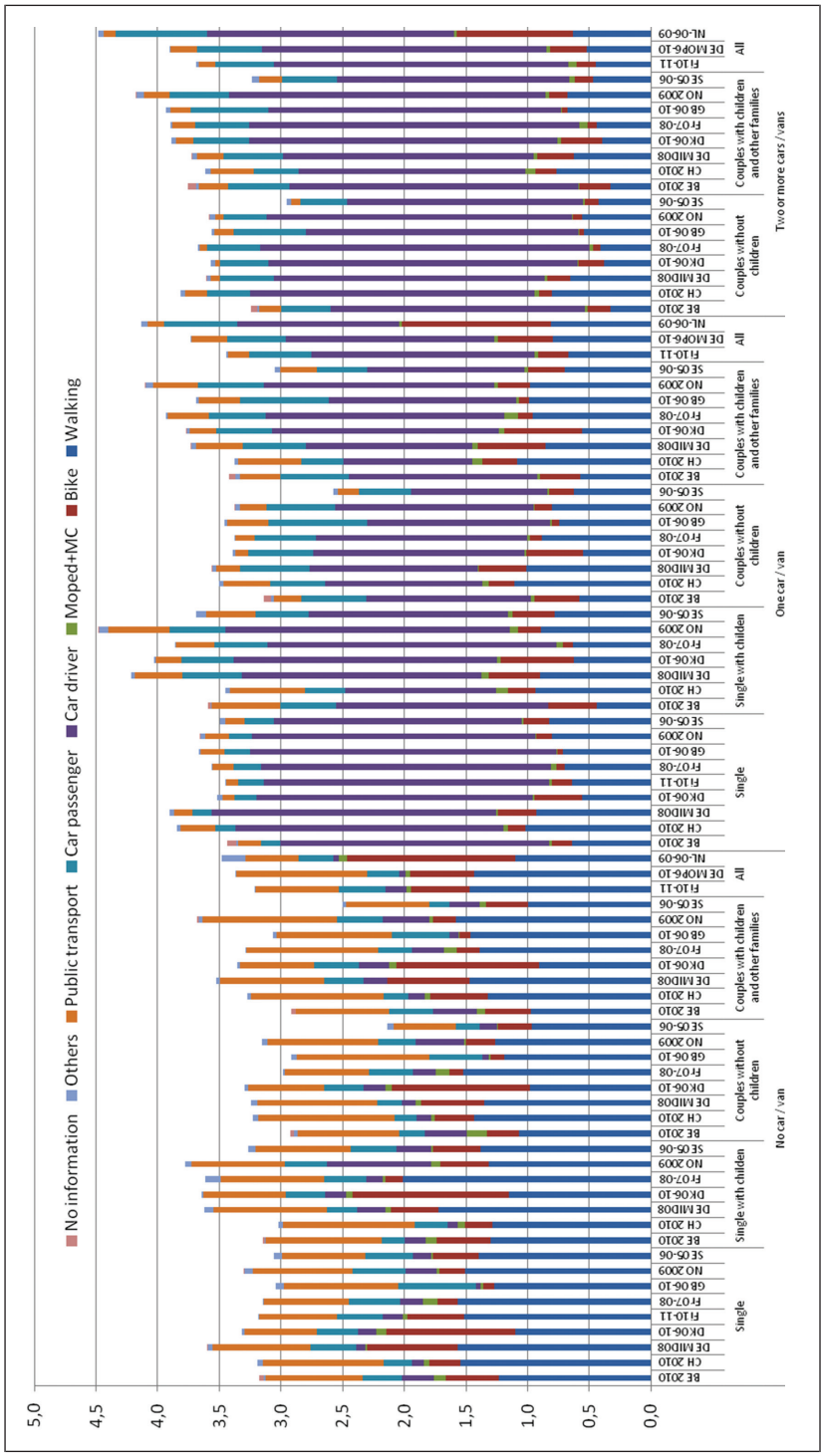


Appendix E *Figure 25: **Distance travelled** in kilometres per traveller per day. For car-ownership, family type, and modes*

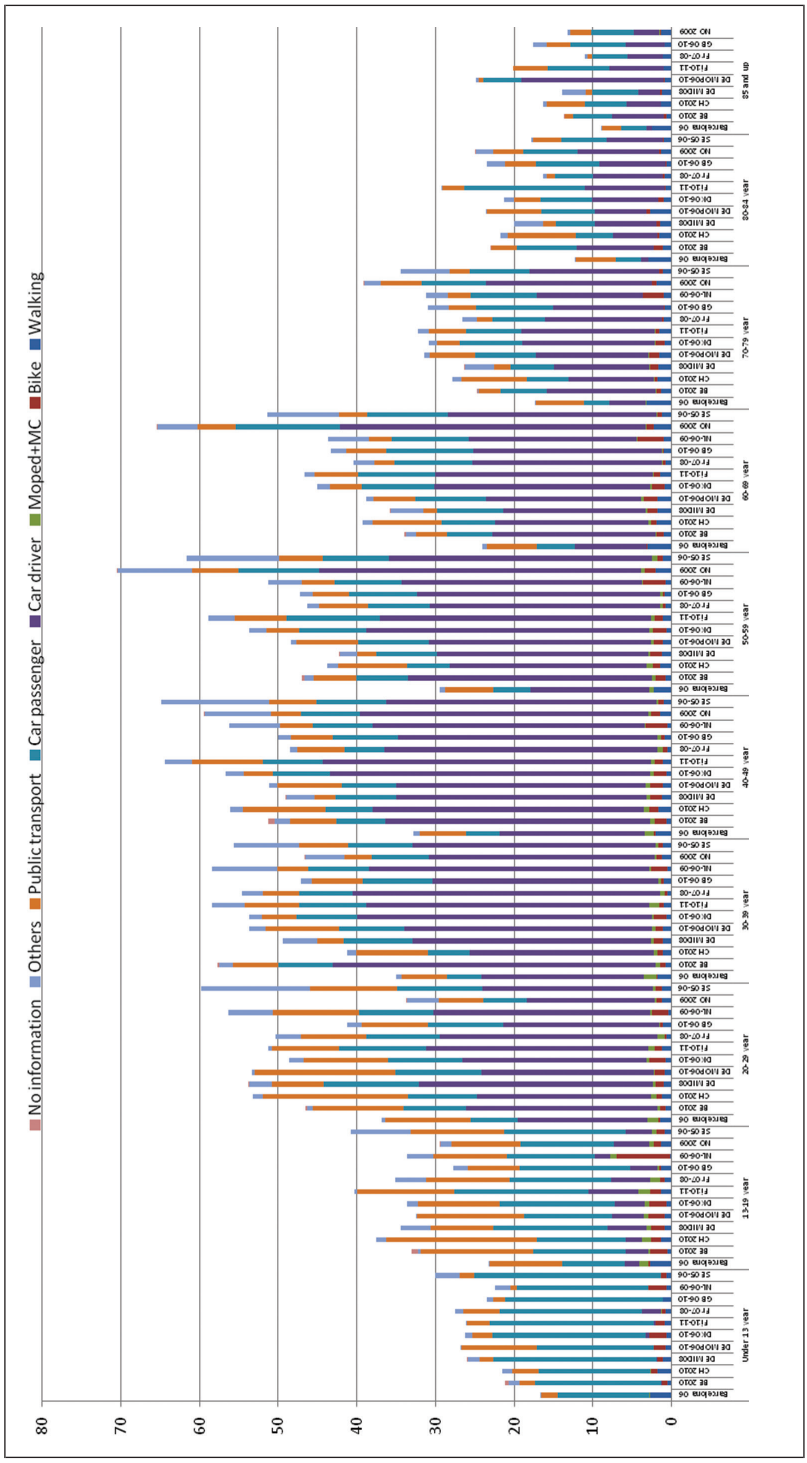
Appendix E *Figure 26:* ***Time use*** *in minutes per traveller per day. For car-ownership, family type, and modes*



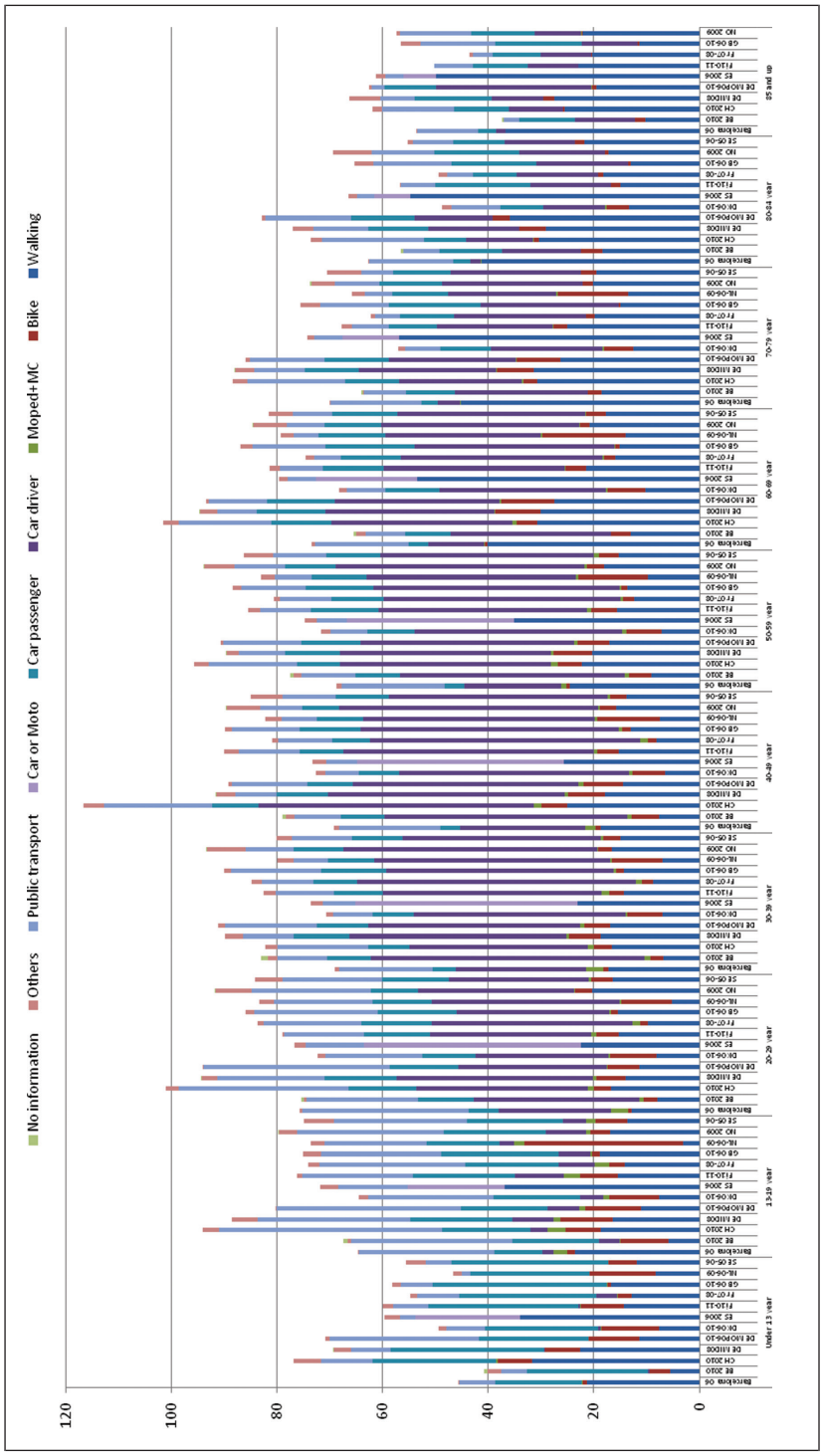
Appendix E *Figure 27:* ***Number of trips*** *per traveller per day. For car-ownership, family type, and modes*



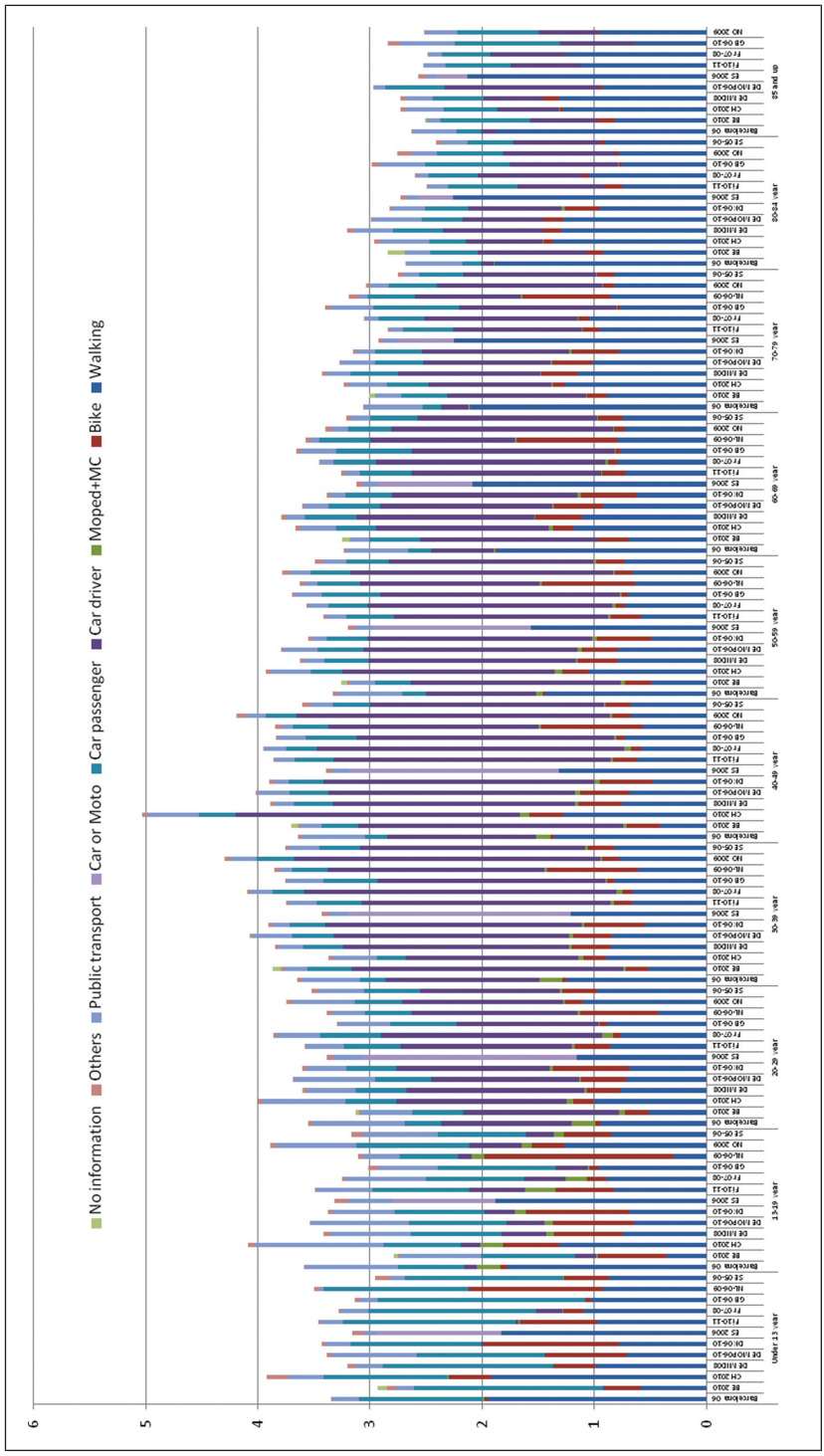
Appendix E *Figure 28:* ***Distance travelled*** *in kilometres per traveller per day. For age groups and modes*



Appendix E *Figure 29: **Time use** in minutes per traveller per day. For age groups and modes*



Appendix E *Figure 30:* ***Number of trips*** *per traveller per day. For age groups and modes*



Appendix F: Calculation of estimated kilometres per traveller per day for Spain

Table 1: Calculation of estimated kilometres per traveller per day for Spain

Time use bands	Main mode	Mean distance	Share of walking and bike	Share of car and moto	Mean distance	Trips Pr Traveler	Km per traveler
1 to under 5 min	Walking	0,22	95%		0,24	0,0038	0,0009
	Bike	0,66	5%				
	Moped+MC	1,55		3%			
	Car driver	1,43		90%			
	Car passenger	1,48		7%	1,44	0,0154	0,0221
	Others	1,12			1,12	0,0004	0,0004
	Public transport	2,28			2,28	0,0001	0,0003
5 to under 10 min	Walking	0,48	90%		0,56	0,2836	0,1577
	Bike	1,21	10%				
	Moped+MC	2,73		3%			
	Car driver	2,98		85%			
	Car passenger	2,85		12%	2,96	0,1930	0,5713
	Others	2,34			2,34	0,0032	0,0075
	Public transport	2,50			2,50	0,0023	0,0057
10 to under 25 min	Walking	1,13	90%		1,31	0,8343	1,0914
	Bike	2,88	10%				
	Moped+MC	7,16		3%			
	Car driver	8,58		80%			
	Car passenger	8,23		17%	8,48	0,8003	6,7845
	Others	7,52			7,52	0,0252	0,1891
	Public transport	5,23			5,23	0,0608	0,3177
25 to under 50 min	Walking	2,52	85%		3,20	0,3000	0,9610
	Bike	7,09	15%				
	Moped+MC	20,13		3%			
	Car driver	25,09		80%			
	Car passenger	24,69		17%	24,87	0,2936	7,3034
	Others	20,22			20,22	0,0183	0,3700
	Public transport	12,01			12,01	0,0815	0,9788

Time use bands	Main mode	Mean distance	Share of walking and bike	Share of car and moto	Mean distance	Trips Pr Traveler	Km per traveler
50 to under 90 min	Walking	4,33	85%		5,82	0,1360	0,7923
	Bike	14,30	15%				
	Moped+MC	43,13		3%			
	Car driver	55,51		75%			
	Car passenger	57,28		22%	55,53	0,0652	3,6205
	Others	86,90			86,90	0,0053	0,4578
	Public transport	28,95			28,95	0,0252	0,7297
90 min and up	Walking	6,62	80%		10,57	0,0480	0,5071
	Bike	26,35	20%				
	Moped+MC	96,97		3%			
	Car driver	144,39		70%			
	Car passenger	153,97		27%	145,55	0,0314	4,5719
	Others	306,63			306,63	0,0047	1,4505
	Public transport	115,14			115,14	0,0117	1,3519

Publication data form

Research Unit DEST		**INRETS Proceeding** Réf. : R287
Title Survey Harmonisation with New Technologies Improvement (SHANTI)		
Subtitle		
Author(s) Jimmy Armoogum, Peter Bonsall, Michael Browne, Linda Christensen, Mario Cools, Eric Cornélis, Marco Diana, Tristan Guilloux, Henrik Harder , Kristian Hegner Reinau, Jean-Paul Hubert, Martin Kagerbauer, Tobias Kuhnimhof, Jean-Loup Madre, Anastasia Moiseeva, John Polak, Angelika Schulz, Maria Tébar, Lycurgo Vidalakis		**Language** English
Sponsor, co-editor, name and address COST Office Avenue Louise 149 1050 Brussels, Belgium		**Publication date** April, 2014
Summary The SHANTI (Survey Harmonization with New Technologies Improvement) COST Action has coordinated research efforts on data harmonization for transport surveys across Europe. 36 laboratories from 21 countries (of Europe, but also Australia) have worked together in 20 meetings and four working groups, towards the harmonization of methods of production and processing of national data on mobility, taking into account the contribution of new technologies (logs from GPS, GSM, RDS, etc.) in order to make international comparisons. Thus, we have produced correction to cope the bias due to different survey methods and produced robust and consistent daily mobility estimators. This Action was a forum not only to emerge (with Eurostat and DG Move) new projects around data as the collection on a continuous basis and standardization enabled by these new technologies, but also to produce articles and scientific papers.		
Key Words National travel surveys, Data harmonization, New technologies		
Nb of pages 203	**Price** 65 €	**Bibliography** yes

Fiche bibliographique

Unité de recherche DEST	**Actes INRETS** Réf. : R287
Titre Survey Harmonisation with New Technologies Improvement (SHANTI)	
Sous-titre	
Auteur(s) Jimmy Armoogum, Peter Bonsall, Michael Browne, Linda Christensen, Mario Cools, Eric Cornélis, Marco Diana, Tristan Guilloux, Henrik Harder , Kristian Hegner Reinau, Jean-Paul Hubert, Martin Kagerbauer, Tobias Kuhnimhof, Jean-Loup Madre, Anastasia Moiseeva, John Polak, Angelika Schulz, Maria Tébar, Lycurgo Vidalakis	**Langue** Anglais
Nom adresse financeur, co-éditeur COST Office Avenue Louise 149 1050 Brussels, Belgium	**Date de publication** Avril 2014

Résumé

Au cours des quatre dernières années, nous avons coordonné des travaux de recherche sur l'harmonisation des enquêtes de mobilité en Europe pour l'Action COST SHANTI (Survey Harmonization with New Technologies Improvement). 36 laboratoires de 21 pays (d'Europe, mais aussi l'Australie) ont œuvré ensemble, en 20 réunions et 4 groupes de travail, notamment pour harmoniser les méthodes de production et de traitement de données nationales sur la mobilité, tenant compte des derniers apports des nouvelles technologies (traces gps, gsm, rds, etc.), afin de pouvoir réaliser des comparaisons internationales. Ainsi, des travaux portant sur la correction des biais de méthodes entre enquêtes des différents pays ont permis de produire des estimateurs de mobilité quotidienne robustes et cohérents. Cette Action a été un espace de discussion non seulement pour faire émerger (avec Eurostat et la DG Move) de nouveaux projets autour des données, sur la collecte en continu et la standardisation permise par ces nouvelles technologies, mais aussi pour produire des articles et communications scientifiques.

Mots clés

Enquête Nationale Transports, Données harmonisées, nouvelles technologies

Nb de pages	Prix	Bibliographie
203	65 €	Oui

The Shanti COST Action has coordinated research efforts on data harmonization for transport surveys across Europe. Guidelines for harmonizing surveys are not only a statistical problem, because each country also needs to analyze survey results throughout time (time series in the perspective of previous surveys on the same thematic issues with normally the same design) and changing the protocol or the definitions may have an impact on indicators in the sense that the changing behavior could be confused with changes in methodology. Therefore a bottom up approach relying on the skills of the researchers involved in the field of national travel surveys and so quite well knowing their particularities sounds more promising and could lead to more acceptable guidelines. To make results of different survey approaches comparable – it is necessary to develop a methodology or heuristic in which way a transition from one design to another can be derived and how the results of either survey approach can be "translated" or transformed into the results of another.

Illustration: Jimmy Armoogum

Avril 2014

65 €

9 782857 827047

ISSN 0768-9756
ISBN 978-2-85782-704-7

IFSTTAR

EUROPEAN SCIENCE FOUNDATION

ESF provides the COST Office through an EC contract. COST is supported by the EU RTD Framework programme.